A BIOLOGICAL BASELINE STUDY OF THE SIERRA VALLEY MARSH CALIFORNIA - 1976

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Department of Biology
San Francisco State University
San Francisco, California 94132

Hank Chopat jr

PARTICIPANTS

Patricia Bushnell, Student Project Director	Birds and Mammals
Sally Blaisdell	Amphibians and Reptiles
Candis Cooperrider	Fish
Kathleen Groneck	Plants
Anthony James, Steering Committee Member	Birds and Mammals
David James	Arthropods
Kathleen Richardson, Steering Committee Member	Arthropods
Frederick Sommers	Plants
Gregory Sommers	Plants
An Sustarich	Fish
Henry Chapot	Physical Parameters
Frances Cave	Arthropods

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CHAPTER 1
INTRODUCTION

Sierra Valley lies east of the crest of the Sierra Nevada at an elevation of approximately 4,850 feet. It is surrounded by mountains that range in elevation from 6,000 to 8,000 feet. The large Valley (110,000 acres) is a down-faulted basin which was formerly a lake bed and is now filled with sediment up to 2,000 feet in thickness (U.S. Soil Conserv. Serv., 1975). The average annual precipitation is less than 20 inches (most of it falling as snow), but in spring extensive marshes form that drain into the Middle Fork of the Feather River. (Figures 1.01 and 1.02).

Many species of wildlife require marshes as a habitat during a portion or all of their life cycles. The area of such habitat has decreased rapidly in California as marshes have been reclaimed for agriculture and other uses. Cowan (1970) stated that, "... in the upper Sacramento Valley alone nearly three-quarters of marshland habitat existing just 20 years ago has disappeared."

Classes from San Francisco State University have made occasional visits to the Marble Hot Springs area of Sierra Valley for several years. The diversity of wildlife there is outstanding, as has been noted by the Calif. Dept. of Water Resources (1973, p. 204), which referred to this area as a "special wildlife habitat". The report of this agency (ibid.) on the natural resources of the Sierra Valley area is quite extensive but does not provide the kind of detailed, quantitative information on the plants and animals of the Marble Hot Springs area that is an objective of the present study.

In recognition of the fact that Sierra Valley is experiencing substantial changes in land ownership and land-use (Calif. Dept. of Water Resources, 1973, p. 1), we have been motivated to obtain information that might be useful to those in positions to engage in wise land-use planning. Accordingly our objectives were to evaluate the marshes in the Marble Hot Springs area as wildlife habitat, and to provide a baseline description of these marshes. Such a baseline is desirable, of course, in order to detect any impact of future changes in land-use.

Our team of four graduate and eight undergraduate students worked full-time in the field between 7 June and 28 August, 1976, surveying the physical parameters, plants, arthropods, fish, amphibians, reptiles, birds, and mammals of the Marble Hot Springs area.

Fig. 1.01. Map of Northern California showing the location of Sierra Valley.

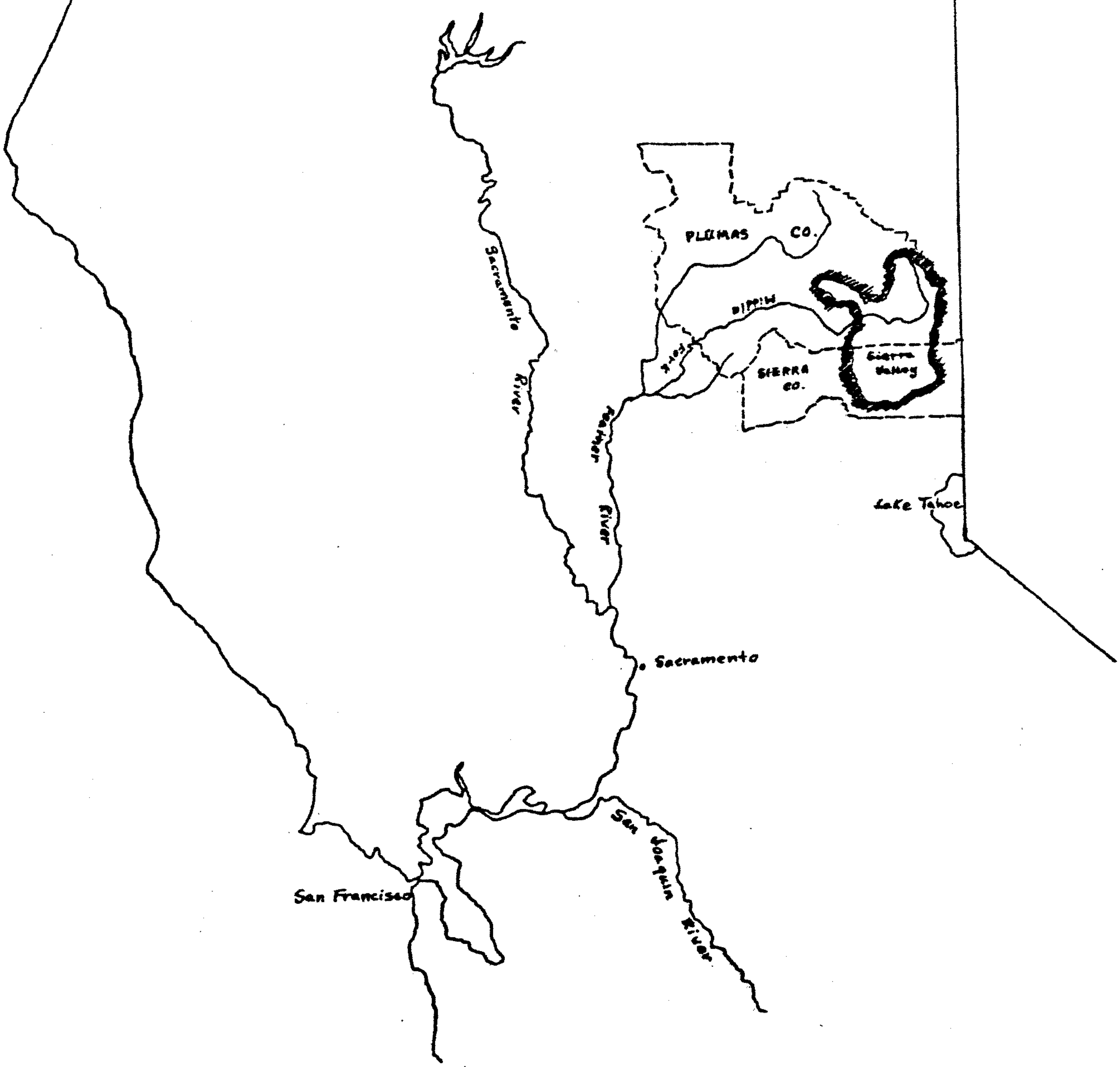
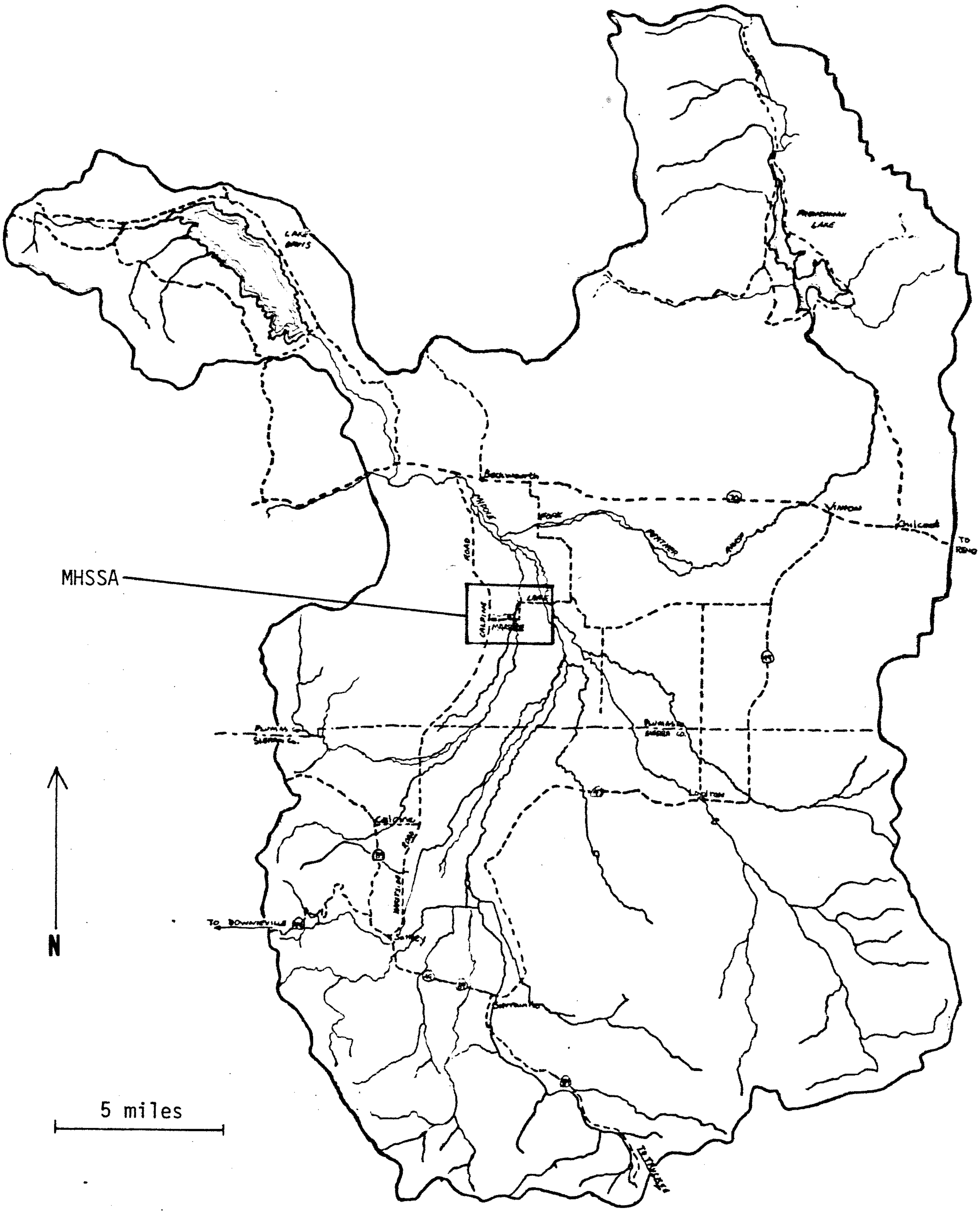


Fig. 1.02. Map showing the location of the Marble Hot Springs Study Area (MHSSA), Sierra Valley, California.



CHAPTER 2
PHYSICAL PARAMETERS

INTRODUCTION

The physical parameters that were measured included atmospheric and aquatic variables. A measurement of the environmental conditions was considered to be important in the baseline study in that a description of the marsh during the summer could yield information useful to the other groups within their studies as well as providing a "baseline" by which future environmental changes can be detected.

The field work was carried out by one operator, working in conjunction with the entire group.

METHODS

The equipment used was portable to avoid vandalism or theft, and therefore equipment had to be transported daily between Camp Leonard and the study area. The amount of time spent in the field was another factor that dictated the variety and frequency of measurements.

Meteorology

A weather instrument shelter was constructed using a crate with slatted openings. It was placed east of Study Site 2 (Figure 2.01). The shelter was painted white.

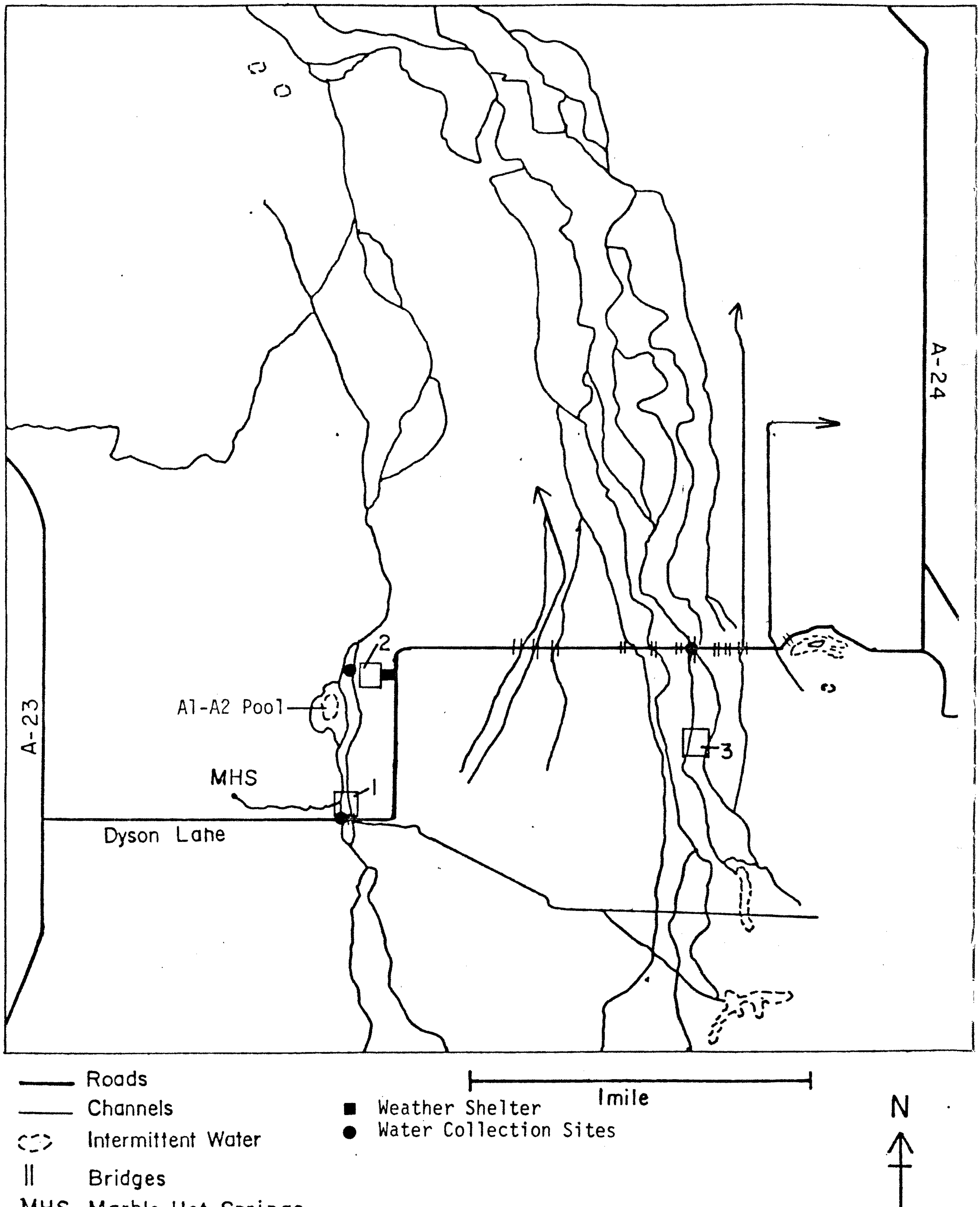
Daily temperatures were recorded with a Tempscribe (Bacharach Industrial Instrument Company) placed within the shelter continually from June 28th to August 27th, 1976. Soil surface and air temperatures (1.2 m) were recorded using mercury-in-glass thermometers shielded with styrofoam cups. This was carried out at hourly intervals when I was in the field. A maximum-minimum thermometer (Taylor Instrument Company, USA) was also utilized to check the tempscribe and manual readings.

Relative humidity readings were taken with two sling psychrometers (Bacharach Industrial Instrumentation) at hourly intervals when possible, and wet and dry bulb temperatures were recorded. A hygrothermograph (Weather Measure Corporation, Model #H311) was also placed in the instrument shelter on Wednesday nights to record relative humidities overnight. The problems of potential destruction by cows or vandalism made it impossible to leave this instrument out at all times. Wind speeds were measured manually with a three-vane anemometer on an hourly basis and the general direction was estimated at that time. Other descriptive meteorological data, such as cloud cover and types (Miller, 1971), were also recorded. A standard grouping, i.e., 0-25%, 25-50%, was employed to define cloud cover. Rainfall was measured with a Tru-check Raingauge hung on a fence post, however, only a cumulative amount for some storms was recorded.

Aquatic Parameters

Physical and chemical analyses of the water in Sierra Valley were carried out mainly within the study sites. The location of measurements and collection of samples in Site 1 was off the low bridge at the southern border of the grid. In Area 2 work was done in a channel approximately 30 meters west of the northwest corner of the grid, while in Area 3 samples were collected off the steel bridge (Figure 2.01). Water samples were collected at an average depth of one-half meter with a Van Doren sampler and a Hach dissolved-oxygen test collecter. Samples were transported in 100 ml nalgene bottles. Temperatures were taken at approximately one-half meter beneath the surface and at the bottom using a mercury-

Fig. 2.01. Map showing locations of weather shelter and water collection sites, MHSSA, Sierra Valley, CA, 1976.



in-glass thermometer attached to a weighted line. Depth readings were taken weekly using a meter stick.

The water clarity was measured with a Secchi disc at the location of water collection in Site 1. This was not feasible in Areas 2 and 3 because the water was inaccessible.

The chemical analyses of water samples were performed in the field and in the laboratory. A Hach dissolved oxygen kit which utilizes the Winkler method was employed.

The pH of water samples was taken with a Photo-volt pH meter and a glass electrode. This meter was calibrated in the field at known temperatures with a buffer on each new day of use. The temperatures, dissolved oxygen and pH were measured in the field on a weekly basis and were also determined on those samples which were brought back to the laboratory. A variety of the chemical components of the water samples were tested with a LaMotte Corporation water pollution test kit that employs two quantitative chemical tests: colorimetric comparisons with standards of known concentration and titration of a sample with reagents of known concentration. The tests were performed biweekly in the laboratory. The components measured were:

Alkalinity	Total dissolved solids
Ammonia Nitrogen	Iron
Total hardness	Nitrates
Calcium Magnesium hardness	Phosphates
Carbon Dioxide	Salinity
Chloride	Sulfides

The reagent system used and type of test employed can be found in the LaMotte Chemical Corporation Instruction Manual.

RESULTS AND DISCUSSION

Meteorology

Temperature

The summer temperatures ranged from below freezing to the upper 90's throughout June, July and August. Many afternoons reached into the mid 80's and higher, as indicated (Table 2.01), whereas the morning lows were generally in the mid to high 30's. The summer weather in the area was generally warm with an average high of 82 F (27.7 C) and was typified by abundant sunshine throughout the surveyed months. Night temperatures often dropped to the mid 30's, especially on clear nights.

Table 2.01. Analyses of temperature at Sierra Valley. (Tempscribe recordings of 52 days beginning June 28, 1976.)

Average daily maximum	82 F	(27.7 C)	
Average daily minimum	39 F	(3.8 C)	
Average daily range	45.4 F	(25 C)	
Greatest daily range	62 F	(35 C)	
Number of days maximum above	90 F	Number of days	16
	80-89 F		23
	63-79 F		4
Number of days minimum	24-35 F		16
	36-45 F		26
	46-53 F		8

Figure 2.02 displays the weekly averages from recorded maximums and minimums and the lines show the trends encountered. The figure also shows the absolute and average weekly temperatures from the recorded information.

On most days the morning temperatures reached their lowest between the hours of three and six a.m. Mornings heated up rapidly on clear days and the mid-morning hours were generally quite warm. The hottest part of the day came between the hours of 12 noon and 4 p.m., as recorded by the tempscribe and as attested to by members of our group. Afternoon field work was nearly impossible on many of the hotter days.

The temperature extremes recorded were consistently higher and lower than those taken at the Sierraville Ranger Station, approximately 15 miles south of the Marble Hot Springs area. This is understandable considering the completely exposed nature of the study area and the relatively protected surroundings of Sierraville. The north end of the valley is cooled by the descent of cold mountain air into it at night.

Relative Humidity

Relative humidity readings were taken at various intervals during the day and on nine consecutive Wednesday nights. This recorded data was pooled and arithmetic means calculated. A 60% to 80% range of relative humidity was not uncommon, highs being reached between the hours of four and six a.m. A rapid drop occurred in the early daylight hours as the temperature rose. Afternoon humidity was low, averaging in the low 20's and below on occasion. These low readings may be associated with the heat of the sun, altitude, winds and location of the lee side of the Sierra Nevada. Factors such as storm activity, cloud cover or morning mistiness increased readings above the norm. The relative humidity was found to be slightly higher in the vicinity of the open flooded areas where rates of evaporation and plant transpiration were presumed to be greater.

Precipitation

Precipitation occurred on seven separate occasions during the summer. The greatest amount was recorded during a storm in mid-August. The summer of 1976 was above normal for rainfall at Sierraville. June had 0.3 inches less than normal, while July had 0.22 inches and August 2.3 inches above established norms (Table 2.02). Upon comparison with the data from Sierraville, the rainfall gathered at the study site (Table 2.02) was usually less that at Sierraville and this was also observed in our travel across the valley during the rains. The climatic analysis in the Sierra Valley Natural Resources Study (1973) also indicates this relationship.

Table 2.02. Rainfall at the Study Area and at the Sierraville Ranger Station, summer, 1976. (Rainfall in inches. T=trace; N=none.)

Date	MHSSA	Sierraville	Date	MHSSA	Sierraville
June 9	T	.47	August 15	.52	.05
July 13	N	.03	16	-	.04
15	N	.18	17	-	.04
28	T	.3	18	N	.10
August 2	.52	1.42	20	.16	N
13	.10	.1	22	N	.11
14	-	1.7	23	.48	T

Fig. 2.02. Temperature recordings - tempscribe, MHSSA, Sierra Valley, CA, 28 June - 23 August, 1976.

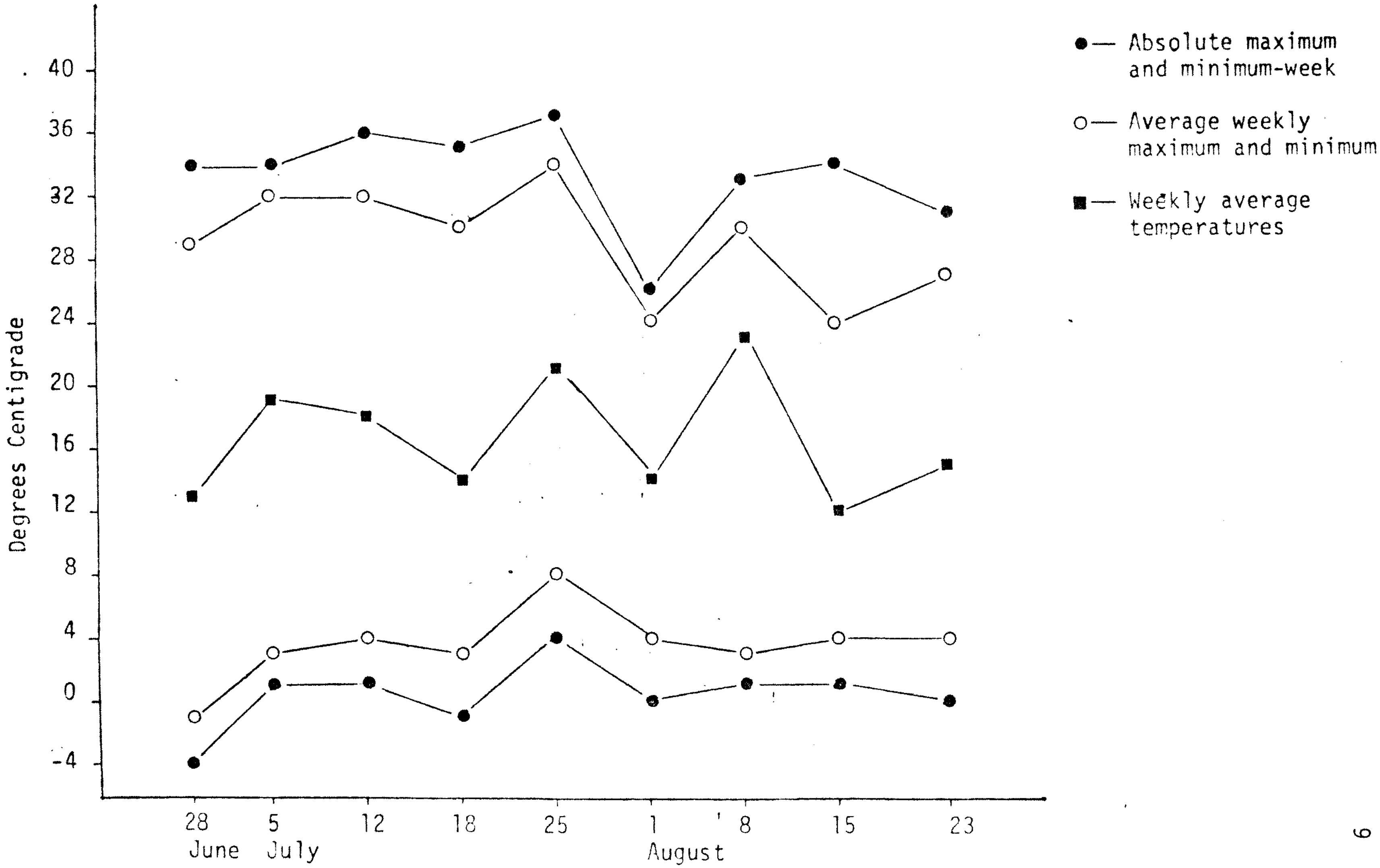
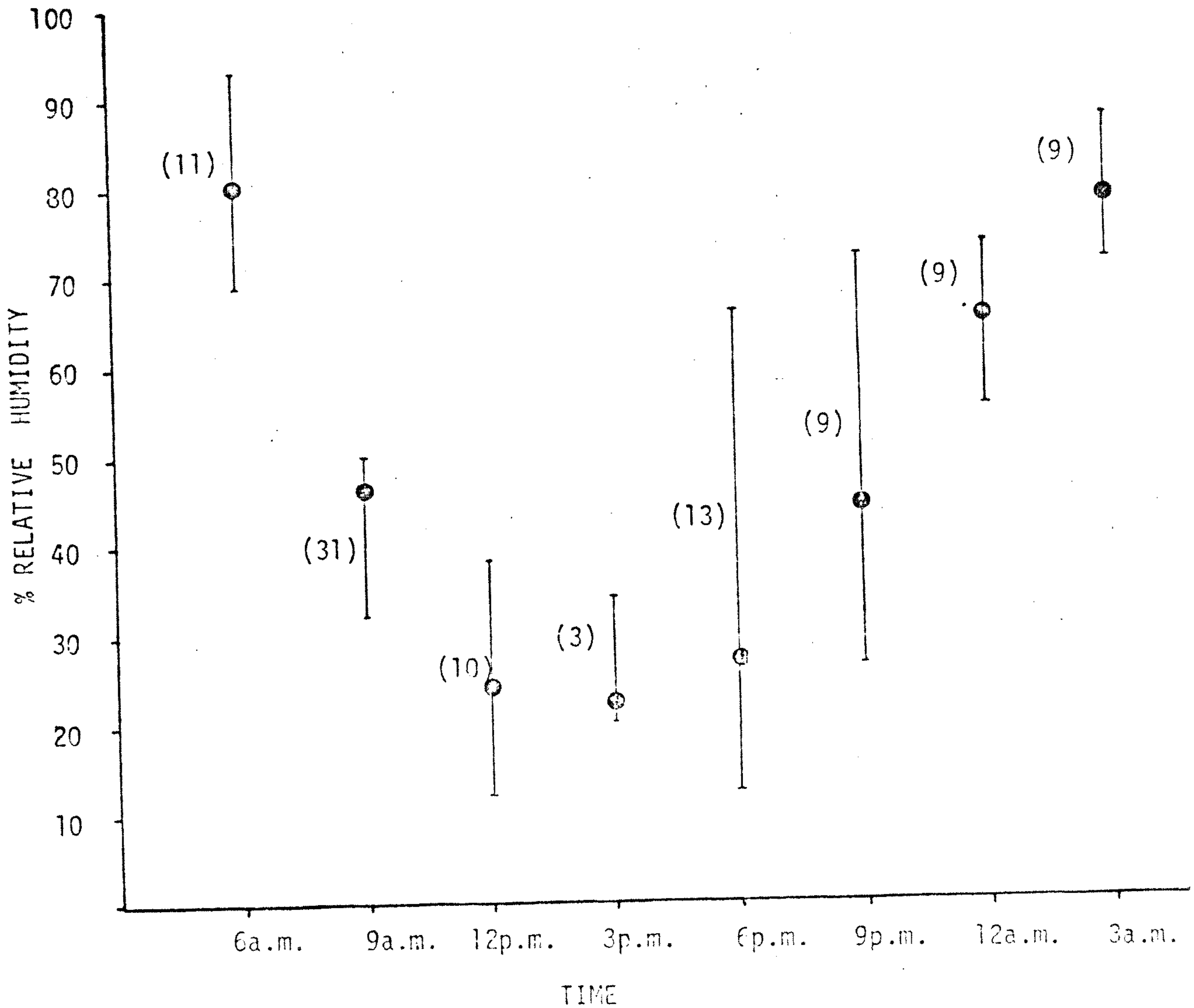


Fig. 2.03. Averages and ranges of relative humidity, MHSSA, Sierra Valley, CA, 7 June - 26 August, 1976. (X) = Number of recordings averaged. Day recordings - sling psychrometer, night recordings - hydrothermograph.



Although the summer of 1976 was wetter than average in much of California, the preceding winter was quite dry. The available record of annual precipitation at Sierraville shows normal or below-normal amounts since 1970, when there was at least a two-year period of very heavy precipitation (Table 2.03).

Table 2.03. Annual precipitation at the Sierraville Ranger Station, 1962-1975.

Year	Annual Precipitation (Inches)	Departure from Normal (Inches)	Year	Annual Precipitation (Inches)	Departure from Normal (Inches)
1975	28.75	1.46	1968	-	-
1974	23.77	-3.52	1967	32.23	6.84
1973	-	-	1966	17.78	-7.61
1972	19.75	-5.64	1965	23.93	-1.46
1971	26.86	1.47	1964	31.09	5.70
1970	38.66	13.27	1963	36.55	11.16
1969	39.17	13.78	1962	37.94	12.55

Wind Speed and Cloud Cover

Most clear days during the summer had some wind. Winds began in the mid-morning hours of nine to ten and by the afternoon wind speeds of 10 to 15 miles per hour were not uncommon. The wind decreased in the late afternoon and ceased by sunset, eight to nine p.m. Occasional high winds of 20 to 25 mph were recorded, coupled with high temperatures and low humidity. A high of 35 mph was recorded, although the wind was usually more moderate, between 10 to 18 mph when it occurred.

The wind came predominantly from the west and southwest all summer, which is usual in California. However, there were some days during June and early July when cold clear days were accompanied by winds from the northeast.

Weather Pattern

Two types of "typical" days can be described from observations of the summer weather in MHSSA: 1) clear and hot and 2) overcast and moderate. A clear and hot day was by far the most prevalent type experienced this summer. This typical day was accompanied by winds and often times by scattered clouds. On the other hand, some days were more cloudy or completely overcast and this affected the temperature extremes and dryness of the air. Nights were generally cold and clear with some variations due to overcast and rainstorm activity.

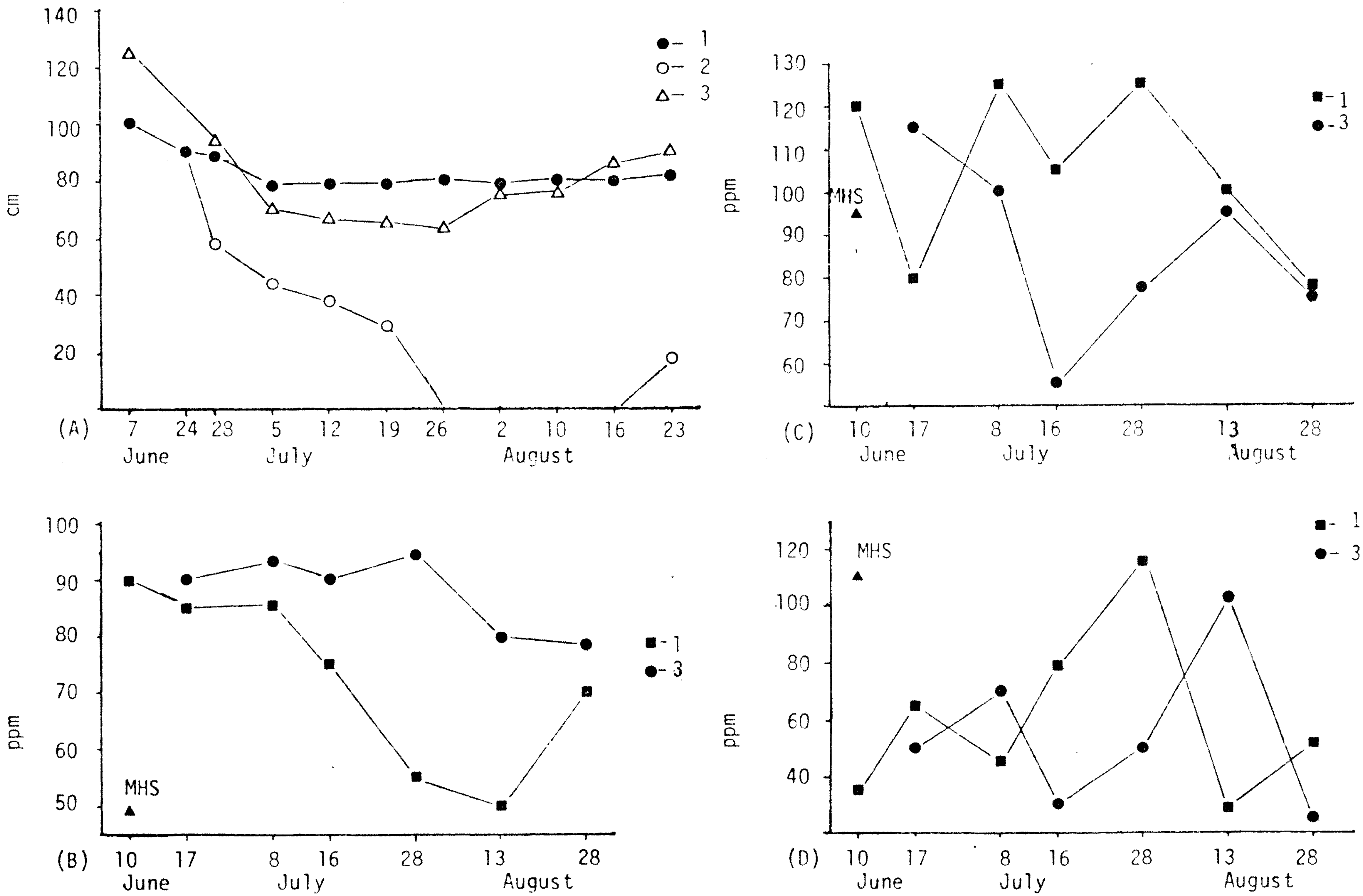
Aquatic Parameters

The locations for collection of water samples and measurements of depth (Figure 2.01) and the mode of collection is described in the methods section of this chapter.

Water Depth

The water in Site 1 connects to the main Sierra Valley channels by a man-made drainage ditch of intermittent flow. The other visible source of water is the Marble Hot Springs. Water levels at Site 1 dropped 20 centimeters during June (Figure 2.04 A) and then leveled off. The man-made ditch that supplies some water to this area had ceased flowing by early July and did not flow again until the rain of mid-August. The water in these channels near Marble Hot Springs remained constant after the initial lowering in June.

Fig. 2.04. Water analyses at three locations (see Fig. 2.01), MHSSA, Sierra Valley, CA, 1976: depth, alkalinity and hardness. (A) Weekly records of water depth, (B) Alkalinity, (C) Total hardness, (D) Calcium hardness.



The channel west of Site 2 was found to be shallower (Figure 2.04 A) than Site 1. The water in Site 2 was spread out into a flat wetland expanse of intermittent water supply. Study Site 2 appears to have a direct connection to the water at Study Site 1 in the Marble Hot Springs area. This flooded pastureland dried up during June and early July, when the channel had ceased to flow. Study Site 2 became dry although the underlying soil remained damp. The channel located west of Site 2 was completely dry by July 26. It remained dry until the August rains, when water entered the area from the channels of Study Site 1. The wide area of open water north of Site was refilled in late August.

Study Site 3 transected the main stream of the Sierra Valley channels, which is a tributary to the head waters of the Feather River. The water is intermediate in variablilty here and the source is the many creeks and streams that enter Sierra Valley in the south. The water level dropped during June, much like Study Site 1; it then leveled off and began to increase in August.

Water Temperatures

The temperature information is inadequate for a thorough analysis of the temperature relations in the Study Sites due to the scattered record it presents. Temperatures were taken at all three collection sites (Figure 2.01). The data offers some general information.

The slow moving waters in this region of Sierra Valley have ample time to absorb solar radiation and the data indicates this. Temperatures recorded at different times of the day showed a range of 15.5 C, from 8.5 C in the morning to a high of 24 C one afternoon. The Marble Hot Springs water had an effect on the temperature of the water in Study Site 1, especially at the mouth of the hot springs channel. The location of water collection in Site 1, however, was never found to be more than a degree above similar readings taken at the other locations.

The water of Marble Hot Springs remains at a fairly constant temperature of 70-74 C. This has been measured in different seasons by students from San Francisco State University (1975) and this summer's readings were within this range.

Water Clarity

Water clarity measurements were taken at Site 1 (Figure 2.01), where a low bridge in the study site provides access to the water.

The best visibility recorded was 22 inches and compared to many surface waters this is considered low (Reid, 1961). The poorest visibility was recorded at the end of July. It was observed that as more water entered the area the water clarity increased. The water in the study sites is relatively slow moving and the poor visibility did not seem to be due to turbulence. The water had "poor" visibility throughout the summer.

Dissolved Oxygen

A dissolved oxygen analysis can yield considerable information as to the fitness of the aquatic environment (Reid, 1961).

Dissolved oxygen analyses were performed at the water collection locations (Figure 2.01) throughout the summer. The tests were carried out in the morning and evening hours, yielding information on the diurnal variation of oxygen content in the study locations. The data shows a range of more than eight ppm with the dissolved oxygen content in the mornings falling within the three to six ppm range. This is considered rather low (Reid, 1961), and is possibly due to use

of the oxygen available by organisms, as well as the decay of organic material (e.g. cattle manure) (Reid, 1961). The slow moving water has little turbulence therefore contact with the air is minimal, thus reducing the potential for increase in dissolved oxygen.

The data shows a rise in the dissolved oxygen content in the afternoon and evening hours, to a range of 8 to 11 ppm. This was observed in all three study sites. This increase is usually associated with photosynthetic activity (Reid, 1961).

The low readings of 3 and 4 ppm are evidence that this is not an especially good environment for animal life. However, the fish inhabitants of the marsh (e.g. carp) are the types that can withstand the poor quality of the water (Chapter 5).

pH

As with dissolved oxygen, pH measurements were carried out at all three study sites. The data shows that the waters at the time of testing were always basic. The soils in the area are alkaline (Soil Conservation Service, 1975) and pH measurements were always above seven on the pH scale and fell in the seven to eight range. The Marble Hot Springs was found to be more basic, from eight to nine. This is considered moderate to strongly basic. The pH information for Sierra Valley indicates the water in much of Sierra Valley is basic (California Department of Water Resources, 1973).

Alkalinity

Alkalinity in natural waters is usually a function of the carbonate, bicarbonate and hydroxide components of the water. The results from this analysis are shown in Figure 2.04 B. These results show that the alkalinity in the study area is from bicarbonates exclusively, as the "P" or phenolphthalein alkalinity was zero (APHA, 1971). The alkalinity of a water supply causes the basic pH recordings. Repeated measurements of the same sample varied by $\pm$ 2 ppm.

Calcium, Magnesium and Total Hardness

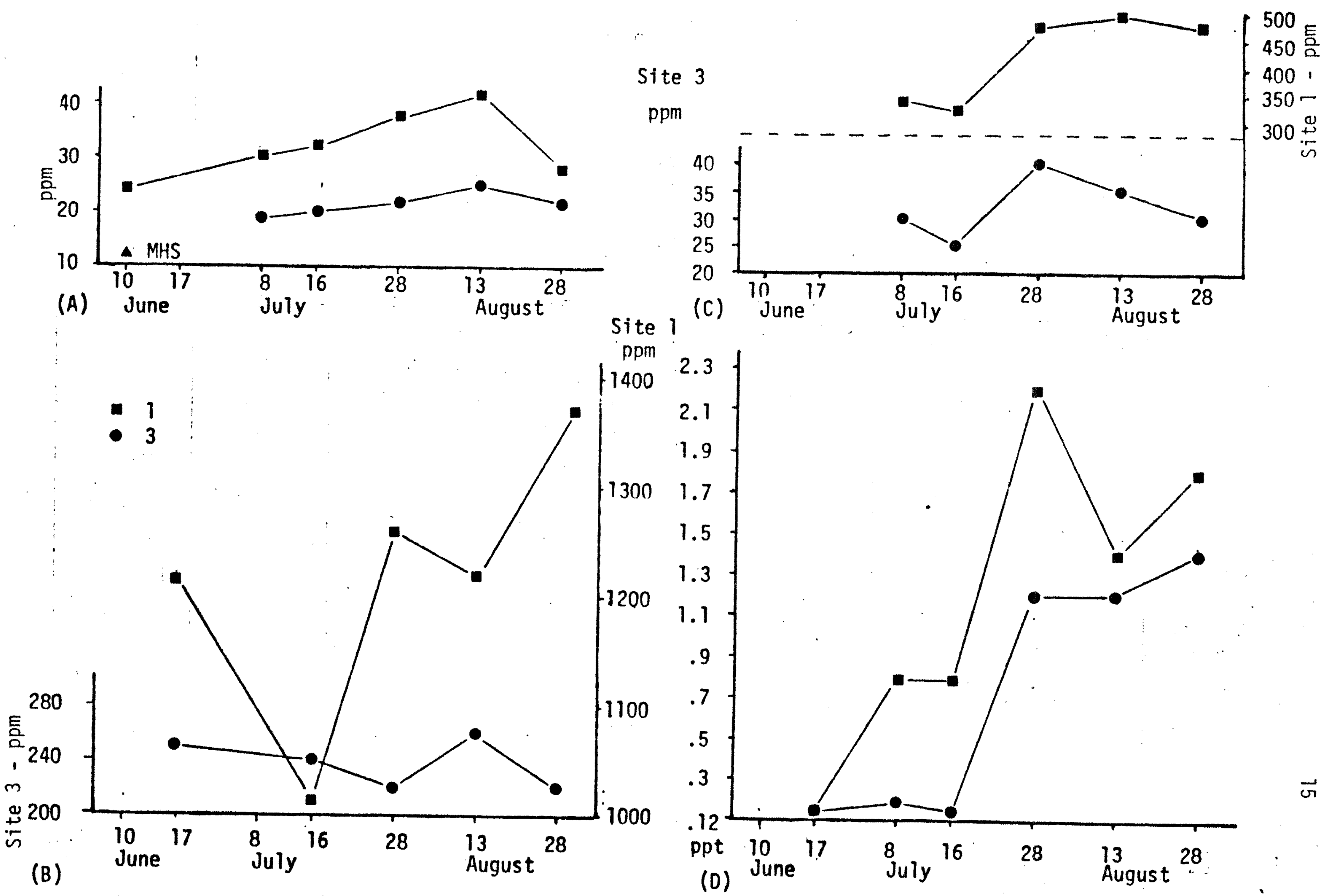
The total hardness (Figure 2.04 C) generally represents the total concentration of calcium and magnesium ions. These are major ions in water that will precipitate soap, and this is one of the characteristics of hard water. The graph shows a range of hardness levels that places the waters tested in the medium-hard to hard range (Renn, 1970). The data from Site 1 indicates that the water was more "hard", consistently than the samples from Site 3, which is the main channel in the area and has a steady water supply. Site 1 could be affected by the water from the Marble Hot Springs but a preliminary test on June 10 (Figure 2.04 C) shows that the hot springs water was only medium-hard, 95 ppm, at that time.

The calcium hardness was also tested and the data is given in Figure 2.04 D. The magnesium hardness is found by subtracting the calcium concentration from the total hardness.

Carbon Dioxide

Carbon dioxide data is shown in Figure 2.05 A. The analysis at Marble Hot Springs shows the lowest reading of 15 ppm, due to the high temperature at collection (40 C). Collections at Sites 1 and 3 show a range from 20 to 40 ppm during the summer. The recorded amounts at Site 1 were higher than at Site 3 throughout the summer.

Fig. 2.05. Water analysis at two locations (see Fig. 2.01), MHSSA, Sierra Valley, CA, 1976; (A) Carbon dioxide, (B) Total dissolved solids, (C) Chlorides, (D) Salinity.



Chlorides

The analysis for chlorides is shown in Figure 2.05 C. The water at Study Site 1 had a chloride concentration in the 300 to 500 ppm range. This is higher than Site 3 which had readings in the 25 to 40 range. The recommended maximum amount in drinking water set by the USPHA is 250 ppm.

Dissolved Solids

Dissolved solids in this test (Figure 2.05 B) were defined as the main dissolved solid components, sulfate, bicarbonate and chlorides of calcium, magnesium and sodium. These are also known as the products from evaporation of a filtered sample (Reid, 1961).

The water from Site 1 had a much higher concentration of dissolved solids than Site 3. Site 1 had too much dissolved solids in terms of drinking water standards, and even for irrigation of crops is considered high (Renn, 1971). The United States Public Health Association recommends a dissolved solids limit of 500 ppm for drinking water although water with up to 1000 ppm may be used.

Salinity

The salinity of a water sample is defined as a term used to describe the total solid content of water (La Motte Corporation, 1970). Site 1 reached a maximum of 2.3 parts per thousand on July 28 (Figure 2.05 D).

Ammonia Nitrogen, Nitrates, Iron,Phosphates and Sulfides

The comparitor did not have values for extremely low concentrations of these chemicals and it is assumed that the concentrations are below the minimum measurable amounts of the apparatus (Table 2.04).

Table 2.04. Water analyses at Sierra Valley Marsh, 1976. Ammonia Nitrogen, Nitrates, Iron, Phosphates and Sulfides. (The "0" represents no color development, the "T" stands for a trace of color observed.) (SS1 - Study Site 1, SS3 - Study Site 3, MHS - Marble Hot Springs)

Date		Ammonia Nitrogen			Nitrates		Iron		Phosphates			Sulfides		
		SS1	SS3	MHS	SS1	SS3	SS1	SS3	SS1	SS3	MHS	SS1	SS3	MHS
June	10	-	-	-	-	-	0		0		0	0		0
	17	-	-	-	0	0	0	0	0	0	0	0	0	-
July	8	T	T	T	T	T	0	T	T	T	-	0	0	-
	16	T	T	-	T	T	0	T	T	T	-	0	T	-
	28	T	T	-	0	T	T	T	T	T	-	0	T	-
August	13	0	T	-	T	T	T	T	T	T	T	0	T	-
	26	T	T	-	0	0	0	0	T	T	-	0	0	-

SUMMARY

The average daily maximum temperature was 27.5 C and the average daily minimum was 3.5 C. The relative humidity averaged less than 25% during the afternoon. The amount of precipitation was well below average during the preceding spring and winter. Consequently water levels in the marsh dropped rapidly during June and one of the three study sites had completely dried up by the end of July. However, August was extraordinarily wet; 1.78 inches of rain fell and water levels rose in the marsh.

Analysis of the water showed a high (11 ppm) to low (3 ppm) oxygen concentration that varied with time and place, while water temperatures varied

from 8.5 C to 24 C. The water was alkaline at all sites and one site had chloride and dissolved solid concentrations that exceeded standards for drinking water.

CHAPTER 3
PLANTS

INTRODUCTION

The flora of Sierra Valley is largely a mixture of elements from the Sierra Nevada to the west, and the desert-like Great Basin to the east. Most of the dominant plants of the Marble Hot Springs Area are fairly common, cosmopolitan species of wide distribution. A considerable number of species are adventive weeds or escapes which are commonly introduced into agricultural areas.

The plant study was done by three persons. Fred Sommers worked solely on Study Site 1 and on the algae of the Marble Hot Springs; Greg Sommers worked solely on Study Site 3 and together they did the ten-point frame survey and were chiefly responsible for the collection and identification of the plants.

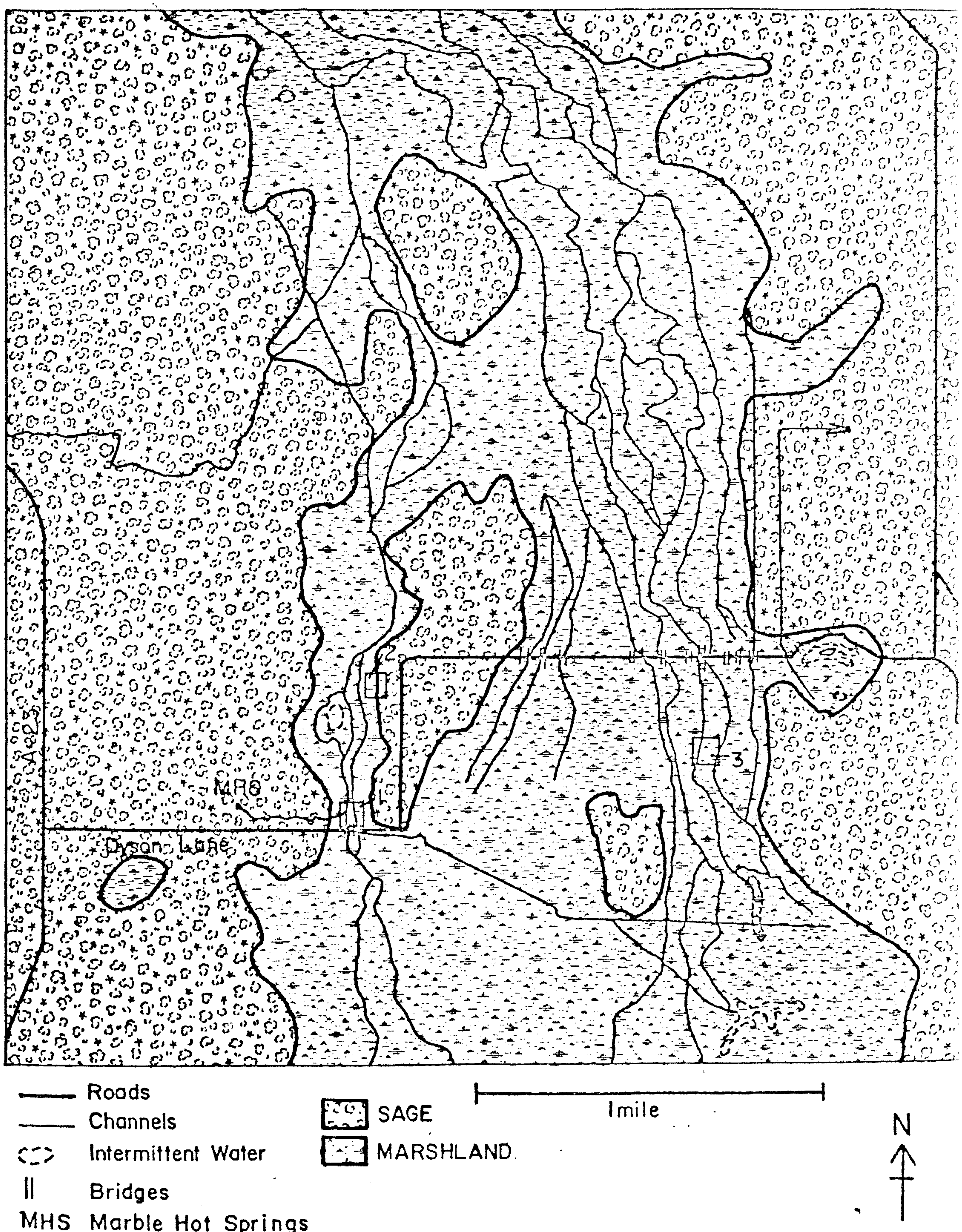
METHODS AND MATERIALS

The focus of the botanical survey was on the marsh and aquatic plants associated with the wetlands and waterways. Plants of the adjacent habitats were also included in our study. Plant specimens were collected and pressed as described by Porter (1967, p. 44). Field notes were taken for each specimen. Information noted included the name and/or description of the plant, surface soil texture and moisture, plant associates, and location within the Marble Hot Springs Area. Most pressing was performed in the field. Specimens were dried outdoors, and then stored in a sealed cabinet containing the fumigant para-dichlorobenzene. With the aid of binocular dissecting microscopes, specimens were identified using keys in Munz (1968), Mason (1957) and Abrahms (1923). Identifications were verified by comparison of specimens with those in the herbaria at San Francisco State University (SFSU) or the California Academy of Sciences (CAS). The plants collected will be deposited in the herbaria at SFSU, CAS and the Sierra Nevada Science Field Campus (SNSFC).

In the vegetation analysis, we employed the point intercept, line transect technique (adapted from Phillips, 1959, p. 38). Five parallel 100 m long transects, running from east to west, were taken on each of the three study sites. The transects ran along the north and south boundaries and at 25 m intervals in between. Only on Study Site 1 was this varied by running the southern transect 12.5 m north of the boundary in order to avoid the disturbed, unrepresentative vegetation along the roadway. This survey was conducted twice during the summer, between June 27 and July 8, and again between August 9 and 14.

To collect the data, a 25 m nylon line marked off in 1 m intervals was tied between the grid stakes just above the vegetation. At each meter, a plumb line was dropped to the ground. The name of the plant struck was recorded. When the line did not strike a plant, "bare ground" was recorded. When first surveyed, observations of soil moisture, plant height, and maturity were recorded. The last two items were dropped from the second survey, as cattle had grazed heavily in these areas, making such determinations unreliable. Since we were often unable to ascertain the species or even family of a plant, we used more general categories, such as "rushes", indicating that the plant in question belonged to either the Juncaceae or Cyperaceae.

Fig. 3.01. General pattern of vegetation and three study sites for vegetation analysis, MHSSA, Sierra Valley, CA, 1976.



In addition to the point-intercept method, the ten-point frame transect method (Phillips, 1959, p. 39) was used along one transect line in Study Sites 1 and 3 on July 26. The one-meter long frame was placed perpendicular to the line, at one meter intervals. As each pin was pushed down, a record was made of the plant touched first. If none was hit, then it was so noted.

We mapped the three study sites delineating dominant plant types, such as "tules", "salt grass", and "floating aquatics". Measuring distance by pacing, we mapped the 25 meter-square grid quadrats on separate sheets of graph paper. These maps were later assembled to form a composite map showing the entire study site. Data collected in surveying the transects was used to verify the location of well-defined areas, such as watercourses. The maps of the three study sites were reduced for field use and general descriptive purposes (Figures 3.02, 3.03 and 3.04).

Measurements of soil moisture were taken weekly from July 15 to August 5, 1976, using Water Moisture Indicator #1-0434, made by the Peerless Instrument Company of Houston. The measurements were taken at 16 designated points on Study Site 1.

Marble Hot Springs flows from its source into the channel located at Study Site 1. Its meandering course, 300 m long, is roughly one-half meter wide. Samples of algae were collected from the hot springs channel and identified by specialists at SFSU.

Observations of flowering stages of Typha latifolia were recorded weekly from July 13 to August 21, 1976. A stand of 30 flowering plants was chosen for observation because of its isolation from the grazing cattle. Success and maturity of spikes, as indicated by approximate diameter, color and posture (drooping or erect) were recorded. A count comparing the number of this year's T. latifolia spikes with last year's was made by recording age (this year's or the previous year's) for 100 spikes in another stand not accessible to cattle. Success of this year's spikes was again noted.

Photographs were taken weekly from July 5 to August 21, 1976, to record changes in vegetation and water level fluctuations, using a 35 mm, single lens reflex camera and Kodachrome 25 and 64 films.

RESULTS

Collection of Specimens

The collection of plant specimens was made during the months of June through August by careful search of the study sites and the surrounding area. The distinct habitats and their intergradations yielded a wide variety of forms. Undoubtedly, some species were missed or overlooked due to the unusually early drought, cattle grazing and our own limitations.

The species, which were identified according to Munz (1968), numbered 146, in 43 families, and are arranged phylogenetically, by family, according to the herbarium index of Dalle Torre and Harms with additions from Engler and Diels, Edition 11 (Appendix I). Along with the name of the plant, some descriptive information is presented. Under the heading "Habit" the following categories were used: floating (F), erect (E), suffrutescent (S), woody perennial (WP), and low/spreading (L). "Abundance" is described as: rare (R), occasional (O), frequent (F), common (C), and abundant (A). "Habitat" refers to the edaphic preferences and plant association among which the species usually

Fig. 3.02. Vegetation of Study Site 1, MHSSA, Sierra Valley, CA, 1976.

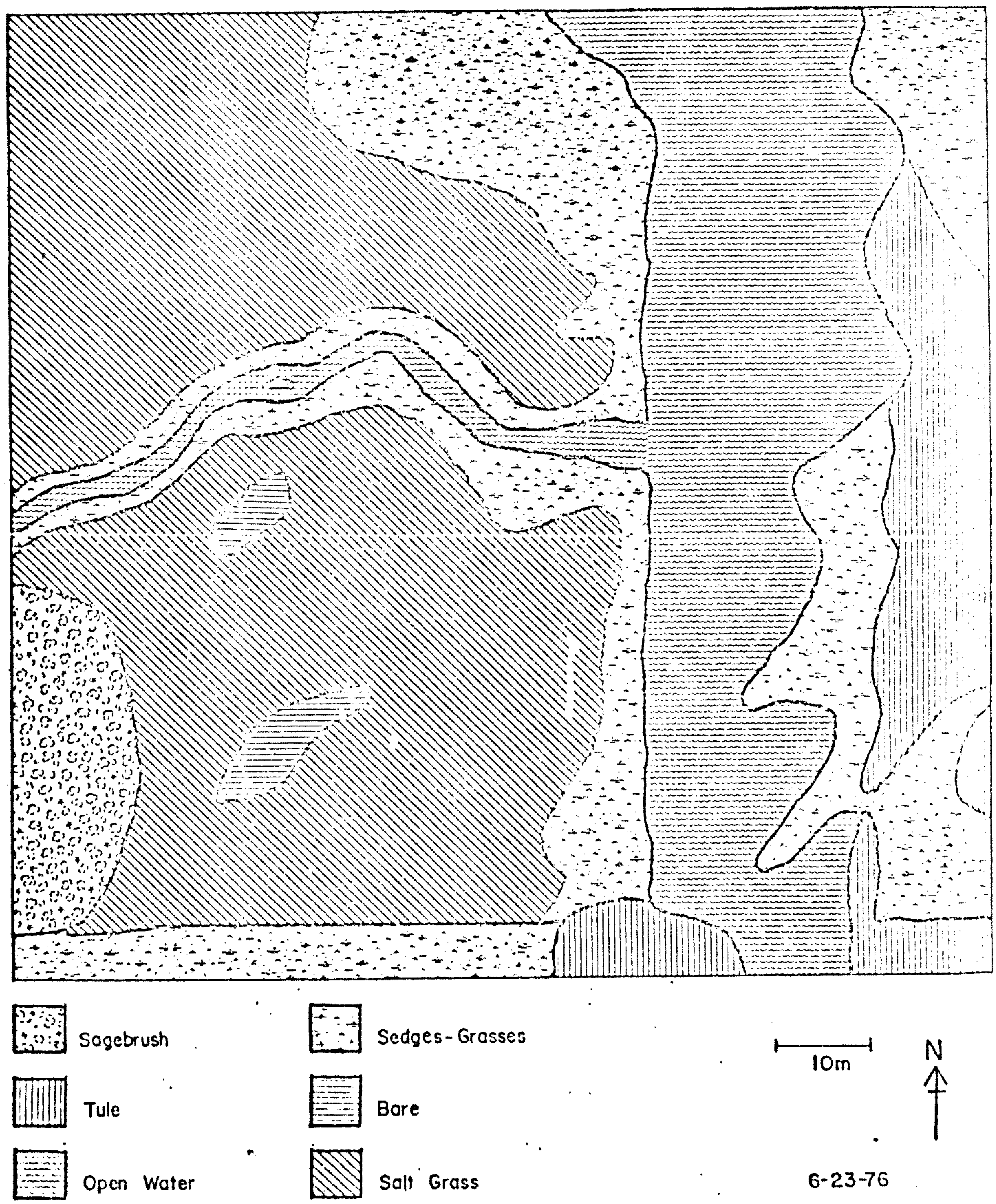


Fig. 3.03. Vegetation of Study Site 2, MHSSA, Sierra Valley, CA, 1976.

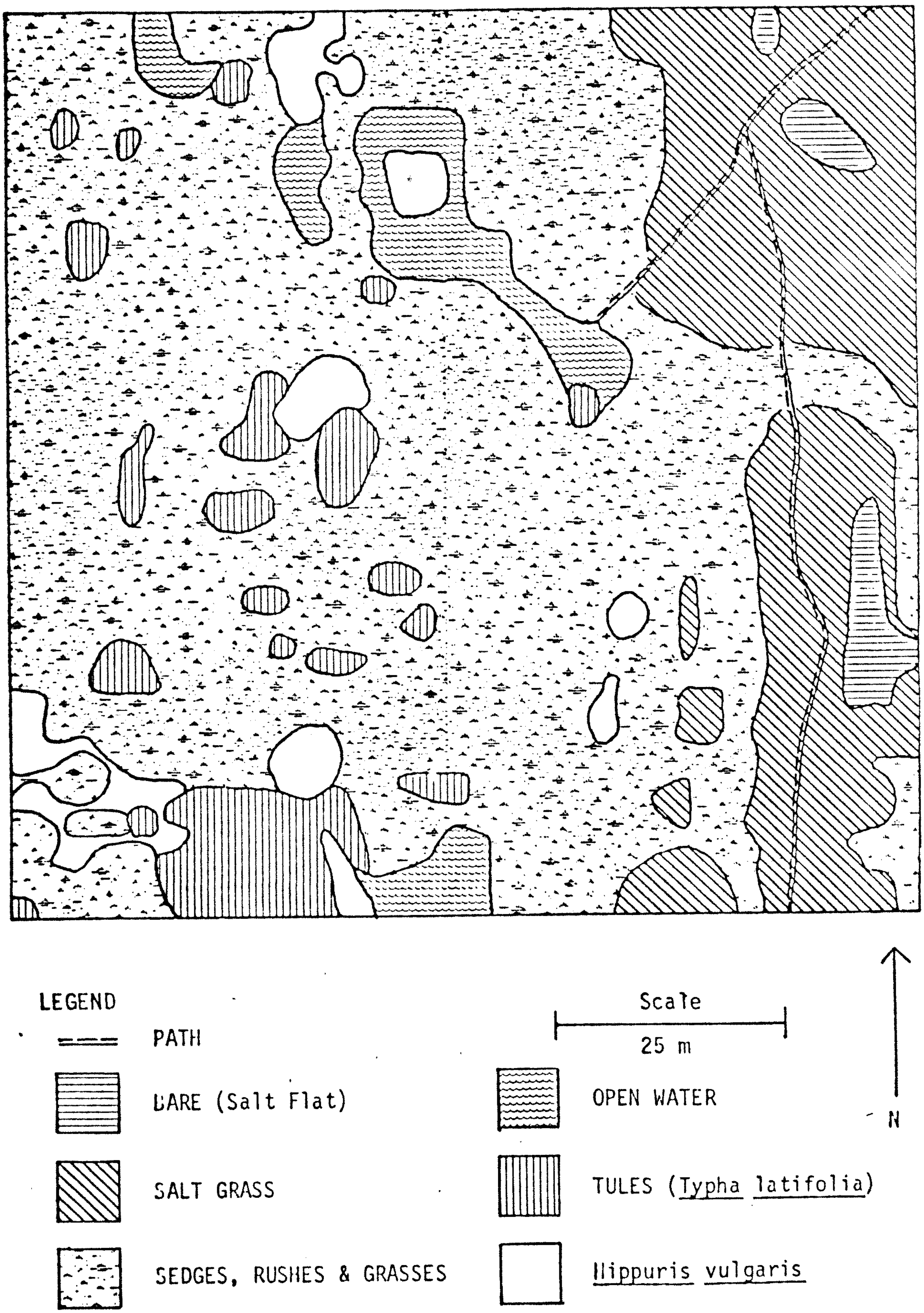
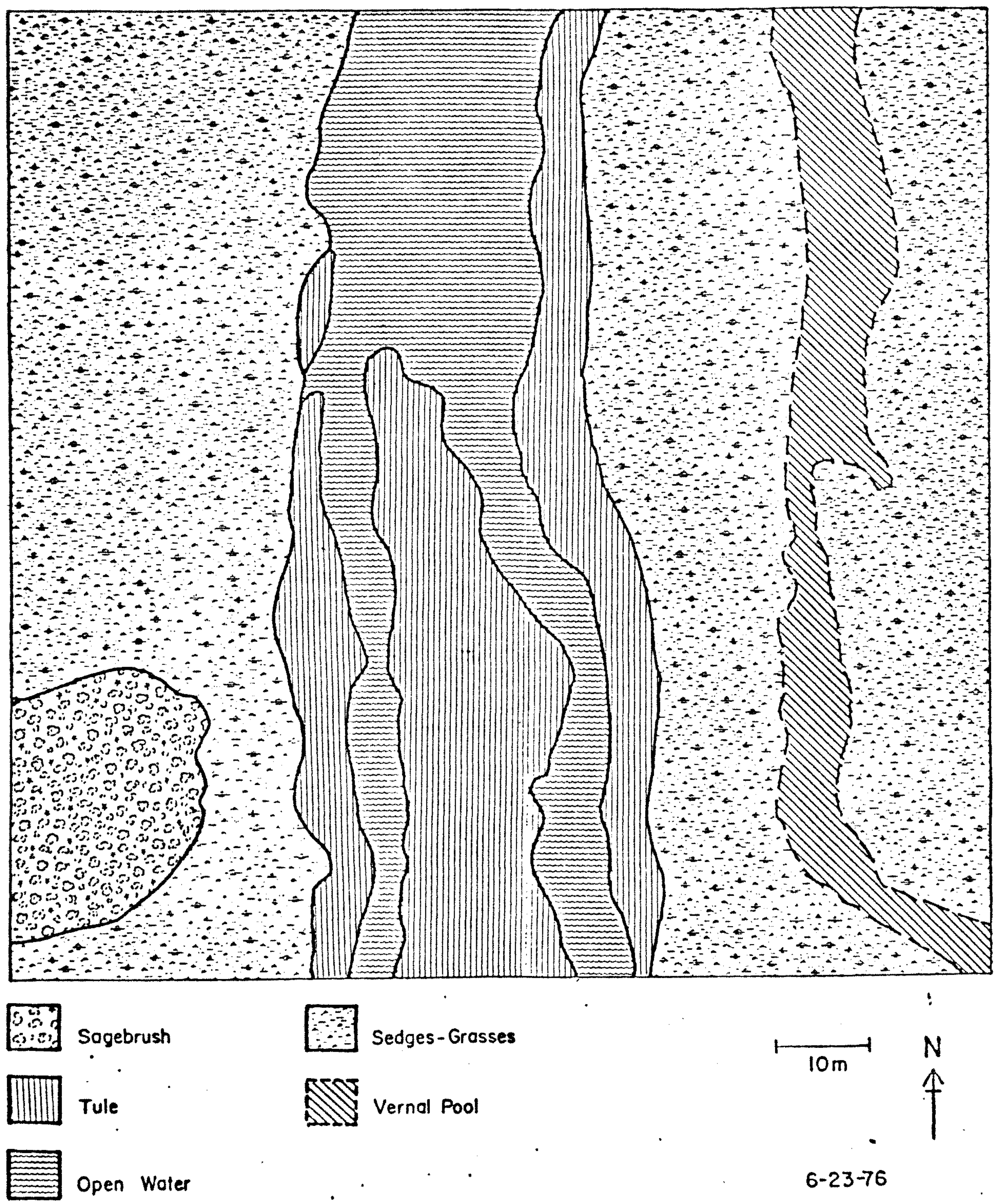


Fig. 3.04. Vegetation of Study Site 3, MHSSA, Sierra Valley, CA, 1976.



occurs: roadcut or similarly disturbed area (R), perennially moist banks and meadows (M), water channels and ditches (W), salt (alkali) flat (SF), seasonally wet meadows including channel overflow and dry channels (SW), and sagebrush scrub (SS). The terms used to describe "Geographic Distribution" are: circumglobal (G), North America (NA), South America (SA), Europe (E), Asia (A), and Pacific Northwest (P) for the more restricted, locally occurring species. If a plant ranges over three or more continents, it was regarded as circumglobal.

Cover, Relative Dominance and Frequency of Plants

The data gathered from the first point intercept transect was analyzed for cover (C), relative dominance (RD) and frequency (F). Cover is defined as the ratio of the total number of points in which a species occurs to the total number of points in the transect times 100; relative dominance, the ratio of the total number of points in which a species occurs to the total number of points of occurrence for all species times 100; and frequency, the ratio of the number of transect intervals in which a species occurs to the total number of intervals times 100 (Cox, 1976, p. 46). The interval used for the frequency determination was 10 m long (10 points). As the total transect length was 500 m (500 points), there were 50 intervals. The graphs in Figure 3.05 show the percent relative dominance of the dominant plants (four percent relative dominance or greater) on each of the study sites. The results for percent cover, percent relative dominance, and percent frequency are presented in Table 3.01. This information, along with all quantitative results which follow, was taken from the first transect (June 27-July 8, 1976), unless otherwise noted.

Results of the Chi-square Goodness-of-Fit Test (Cox, 1976, p.12) which are termed "significant" represent the 95% confidence level, and those termed "highly significant" denote the 99% confidence level.

Study Site 1

The surface of Study Site 1 was 18% water and 82% land in late June. The first transect showed terrestrial cover to be 66% and aquatic cover (plants floating over the bottom) was 78%. Overall cover for the whole study site was 68% (Table 3.01).

Salt grass, *Distichlis*, was the most prevalent plant on the site with 35% RD. The two species of rooted, floating plants found in the north-south water channel were *Myriophyllum spicatum* subspecies *exalbescens* and *Potamogeton pectinatus*, which were grouped together under the heading "aquatics". Combined, they had nearly 21% RD. However, the latter of the two was by far the more abundant. *Eleocharis* sp. and *Scirpus americanus* each had 11% RD, and predominated along the moist banks of the waterways. In addition to the above mentioned dominant plants, species with less than four percent RD are listed in Table 3.01.

When data for the occurrence of a single species was compared from the first transect (June 27-July 8) to the second (August 9-14) using a Chi-square Test, some significant changes were noted to have occurred. There was a highly significant reduction in the occurrence of the grass *Poa* sp. There was a significant decrease in the area covered by aquatic plants. Cover over the whole study site decreased significantly. This was clearly visible as cattle grazing had increased markedly between the two surveys. Differences in the occurrence of members of Juncaceae/Cyperaceae ("rushes") was not significant; however, the individual species could not be compared, as heavy grazing prior to the second transect left many plants unrecognizable. There was no significant change in the

Table 3.01. Cover (Percent) (C), Relative Dominance (Percent) (RD), and Frequency (Percent) (F) of the dominant plants of Study Sites 1, 2 and 3. (Point intercept transects, June 27-July 8, 1976).

	Study Site 1			Study Site 2		
	C	RD	F	C	RD	F
Distichlis	24.0	35.1	58	8.9	25.9	29
Other Cyperaceae/Juncaceae	0	0	0	8.7	25.3	43
Other Aquatics	14.2	20.8	26	0	0	0
Elodea	0	0	0	0	0	0
Eleocharis spp.	7.8	11.4	34	5.3	15.3	31
Scirpus spp.	7.8*	11.4*	32*	0	0	0
Other Gramineae	1.2	1.7	6	1.4	4.1	8
Taraxacum	0	0	0	0	0	0
Agrostis	0	0	0	0	0	0
Poa spp.	6.2	9.1	34	0.6	1.8	8
Myriophyllum spp.	0	0	0	0	0	0
Plagiobothrys	0	0	0	0	0	0
Juncus spp.	2.2	3.2	20	2.0	5.9	12
Alopecurus	0	0	0	0.2	0.6	2
Beckmannia	0	0	0	1.6	4.7	14
Hippuris	0.2	0.3	2	1.4	4.1	8
Glyceria	0	0	0	0	0	0
Typha	1.4	2.0	6	1.2	3.5	8
Veronica	0.4	0.6	4	0.2	0.6	2
Sparganium	0	0	0	0	0	0
Artemisia	0.8	1.2	4	0	0	0
Green Algae (Spirogyra)	0.8	1.2	6	0	0	0
Eryngium	0	0	0	0	0	0
Polypogon	0.2	0.3	2	0.4	1.2	4
Lemna and Spirodela	0.6	0.9	4	0.2	0.6	2
Hordeum brachyantherum	0.4	0.6	4	0.4	1.2	2
Marsilea	0	0	0	0.6	1.8	4
Mentha	0	0	0	0	0	0
Polygonum aviculare	0	0	0	0	0	0
Ranunculus aquatilis	0	0	0	0.2	0.6	2
Trifolium hybridum	0	0	0	0	0	0
Other Compositae	0.2	0.3	2	0	0	0
Navarretia	0	0	0	0.4	1.2	2
Total	68.0	/	/	33.7	/	/

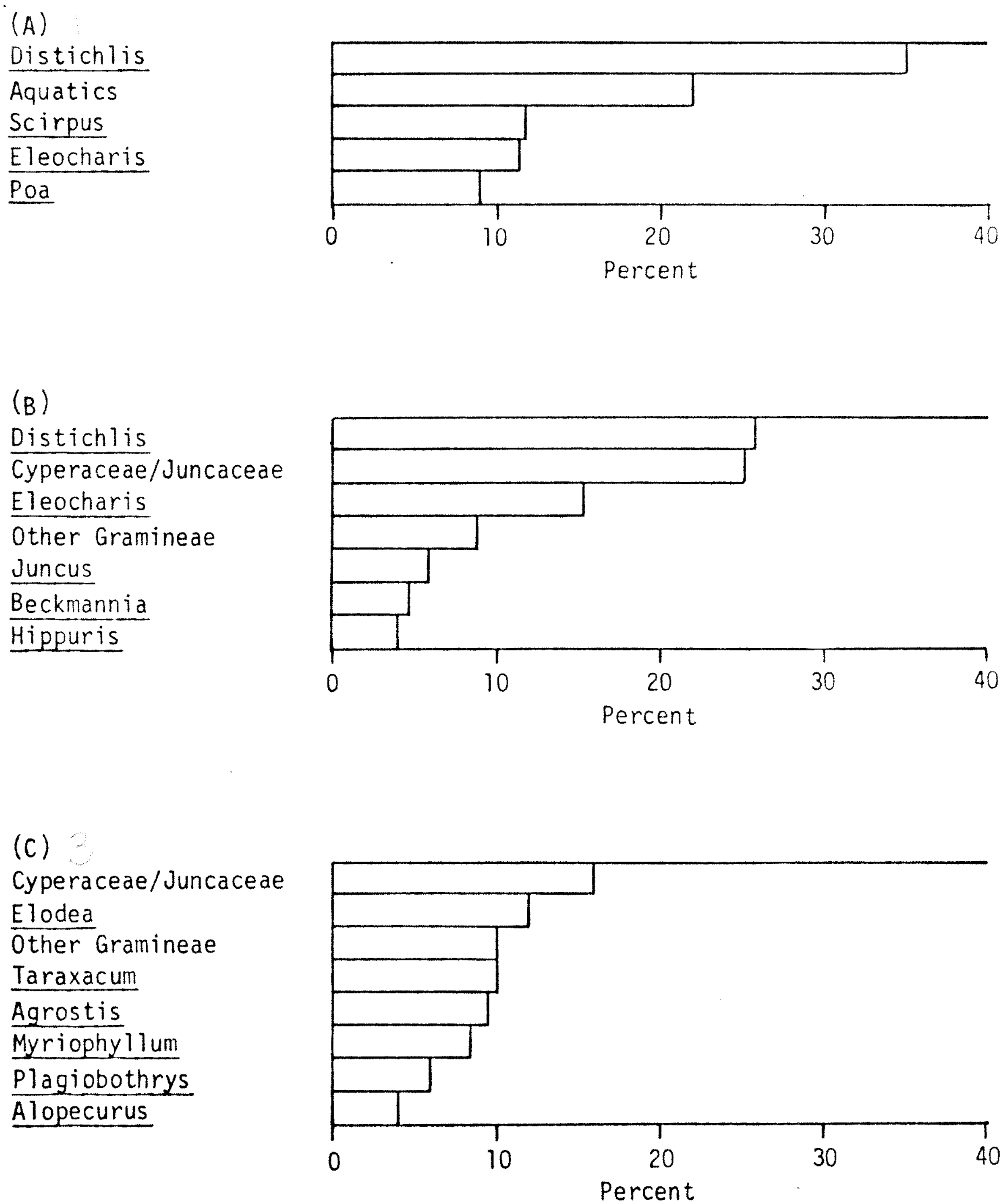
* S. americanus

° S. acutus

Table 3.01 (cont'd).

Marsh Zone (SS 2)			SaltFlat Zone (SS 2)			Study Site 3		
C	RD	F	C	RD	F	C	RD	F
0.5	1.8	6	31.1	71.2	92	0	0	0
11.7	37.9	56	0.7	1.7	8	6.8	16.0	42
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	5.2	12.0	16
5.8	18.9	33	3.7	8.5	23	0	0	0
0	0	0	0	0	0	0.2°	0.5°	2°
1.4	4.5	11	1.5	3.4	23	4.6	10.0	30
0	0	0	0	0	0	4.2	10.0	14
0	0	0	0	0	0	4.0	9.5	24
0	0	0	2.2	5.1	31	0	0	0
0	0	0	0	0	0	3.6	8.5	26
0	0	0	0	0	0	2.4	6.0	16
2.8	9.0	17	0	0	0	0	0	0
0.3	0.9	3	0	0	0	2.2	5.0	16
2.2	7.2	19	0	0	0	0	0	0
1.9	6.3	11	0	0	0	0	0	0
0	0	0	0	0	0	1.8	4.0	14
1.7	5.4	11	0	0	0	0	0	0
0.3	0.9	3	0	0	0	1.4	3.2	10
0	0	0	0	0	0	1.2	3.0	12
0	0	0	0	0	0	0.2	0.5	2
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0.4	1.0	2
0	0	0	1.5	3.4	15	0.6	1.0	2
0.3	0.9	3	0	0	0	0	0	0
0.6	1.8	3	0	0	0	0	0	0
0.8	2.7	6	0	0	0	0.2	0.5	2
0	0	0	0	0	0	0.2	0.5	2
0	0	0	0	0	0	0.2	0.5	2
0.3	0.9	3	0	0	0	0.2	0.5	2
0	0	0	0	0	0	0.2	0.5	2
0	0	0	0	0	0	0	0	0
0	0	0	1.5	3.4	8	0	0	0
30.6	/	/	42.2	/	/	42.0	/	

Fig. 3.05, A-C. Relative Dominance (Percent) of the dominant (4% or greater) plants as determined by point intercept transects on Study Sites 1, 2 and 3, MHSSA, Sierra Valley, CA, 27 June - 8 July, 1976. (A) Study Site 1, (B) Study Site 2, (C) Study Site 3.



occurrence of Distichlis or Typha, but the height of each of these species, particularly the latter, was greatly reduced by grazing.

A filamentous green alga growing in masses in the channel was Spirogyra sp.

Other plants which occurred on the study site but did not turn up in the line transect were: Happlopappus lanceolatus, Bromus tectorum, Ranunculus cymbalaria var. saximontanus, Taraxacum officionale, and Marsilea vestita.

Some of the species found along the road on the southern boundary of the study site were: Circium vulgare, Verbascum thapsus, Taraxacum officionale, Carex nebraskensis, Muhlenbergia asperifolia, and Elymus triticoides.

Study Site 2

Study Site 2 was approximately 73% covered by water over three inches deep at the end of June. There was no standing water in August. The total percent cover was 33.7% (Table 3.01). The terrestrial cover was 42.2%; the aquatic cover, almost entirely emergent aquatic plants, 30.6% (June 27-July 8).

The dominant plants of Study Site 2 (those with 4% or greater RD) were Distichlis spicata, 25.9% RD; Eleocharis spp., 15.3% RD; "Other Cyperaceae/Juncaceae" (not identifiable beyond family), 25.3% RD; Juncus spp., 5.9% RD; Beckmannia Syzigachne, 4.7% RD; Hippuris vulgaris, 4.1% RD; and "Other Gramineae" (those grasses too few for a separate category or not identifiable beyond family), 4.1% RD (Figure 3.05). The plants with the greatest frequencies were "Other Cyperaceae/Juncaceae", 43%; Eleocharis spp., 31%; and Distichlis spicata, 29%. Plants with RD less than four percent are listed in Table 3.01.

Study Site 2 was naturally divided into two distinct zones of vegetation, marsh and salt flat (Figures 3.03, 3.06 and 3.07). Distichlis spicata was the dominant plant of the Salt Flat Zone with 71.2% RD (Figure 3.07). "Other Cyperaceae/Juncaceae", including Eleocharis macrostachya, E. Parishii, Juncus nevadensis, and J. balticus, were the dominant plants of the Marsh Zone with 37.9% RD. Eleocharis spp. (over and above that included in the category "Other Cyperaceae/Juncaceae") was common in both zones: 18.9% RD in the Marsh Zone and 8.5% RD in the Salt Flat Zone. Most plants were found only in one of the two zones: Juncus balticus, J. nevadensis, Beckmannia Syzigachne, Hippuris vulgaris, and Typha latifolia in the Marsh Zone, and Poa sp., Polypogon sp., and Navarretia minima in the Salt Flat Zone (Table 3.01).

The transects taken from June 27-July 8 do not differ significantly from those taken from August 9-14. In the first transects, there was significantly more Cyperaceae/Juncaceae and Distichlis spicata than any of the other plants of the study site. In the second transects, there was again significantly more Cyperaceae/Juncaceae.

Study Site 3

Twenty percent of the surface area of Study Site 3 was covered by water over three centimeters deep at the time of the first transect. The remaining 80% was fairly dry land. Sixty-five percent of the water surface was covered by floating aquatic vegetation. The land surface had only 24% cover. Total cover for the study site was 42% (Table 3.01).

Species which were considered dominant were those having a four percent RD or higher. The largest category was "rushes", which included Carex spp., Juncus spp., Scirpus americanus and Eleocharis spp., with a combined RD of 16%. Grasses comprised 29% of the plants counted, including 9.5% Agrostis, 5% Alopecurus, 4% Glyceria and 10% unidentifiable. Other dominant plants were Taraxacum, 10% RD

Fig. 3.06. Relative Dominance (Percent) of the plants of the Marsh Zone of Study Site 2 as determined by point intercept transects, MHSSA, Sierra Valley, CA, 27 June - 8 July, 1976.

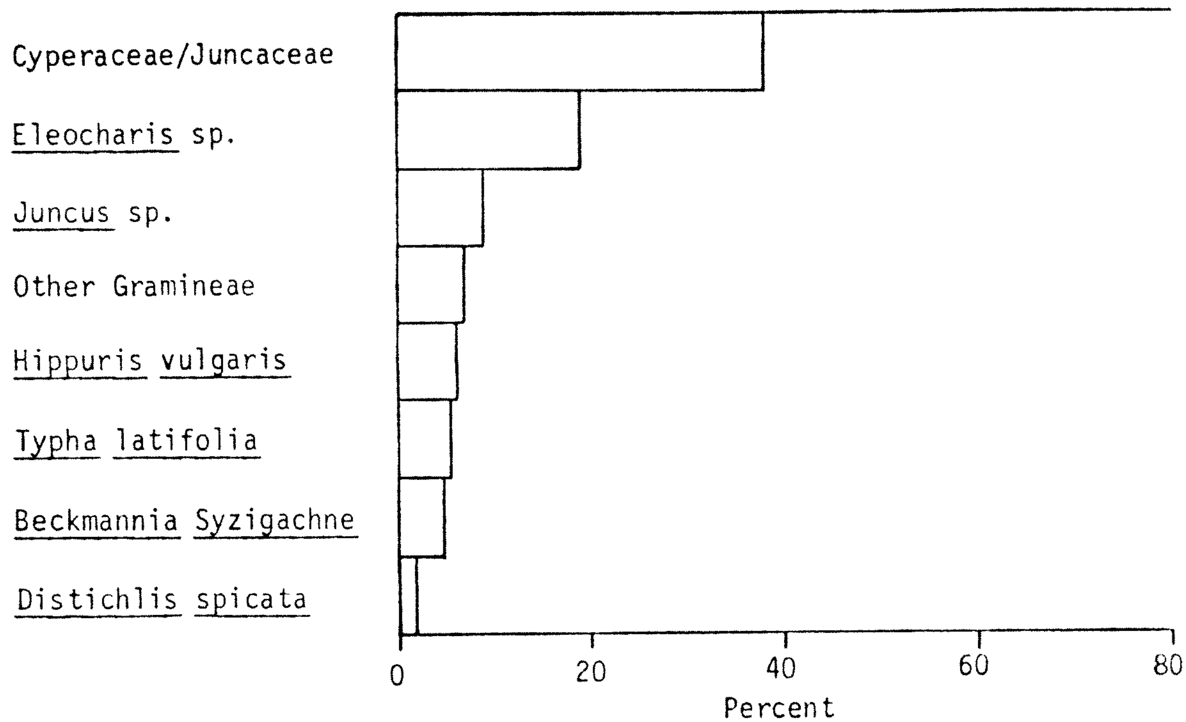
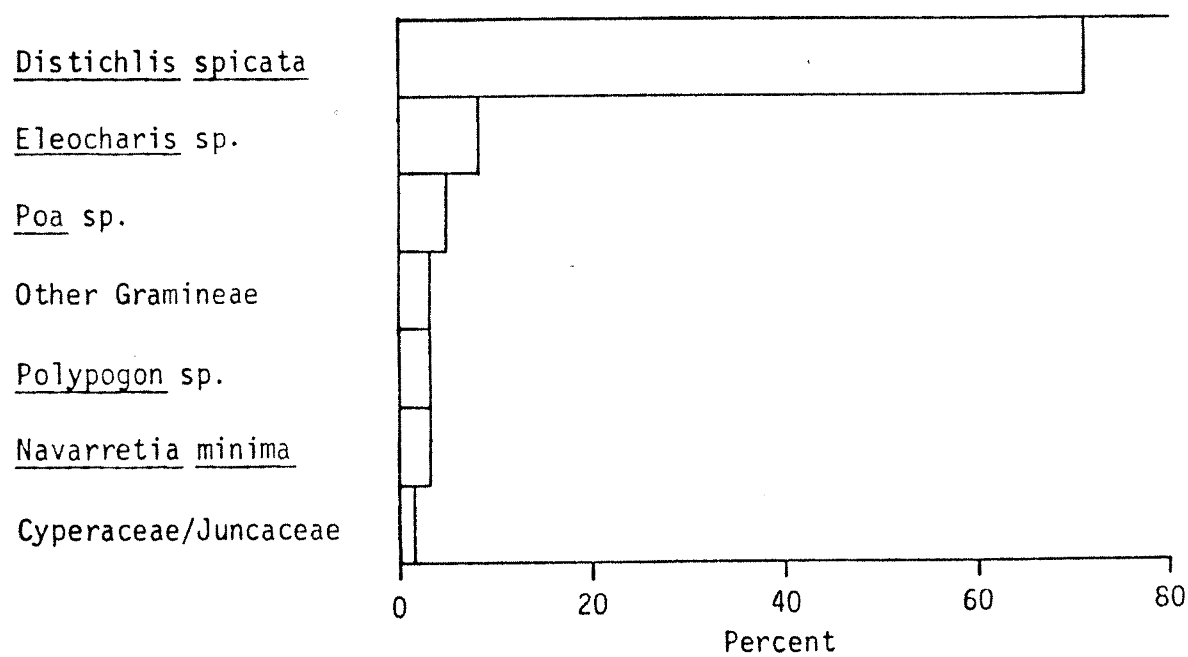


Fig. 3.07. Relative Dominance (Percent) of the plants of the Salt Flat Zone of Study Site 2 as determined by point intercept transects, MHSSA, Sierra Valley, CA, 27 June - 8 July, 1976.



and *Plagiobothrys*, 6% RD. The dominant aquatic species were *Elodea*, 12% RD and *Myriophyllum* spp., 8.5% RD. Additional species whose occurrence was minor are listed in Table 3.01.

Other plants which were not encountered in the transect, but were noted as occurring on the study site were *Downingia*, *Euphorbia*, *Circium vulgare*, *Potamogeton amplifolius*, *Nuphar*, *Ranunculus Macounii*, *Potentilla flobelliformis* and *Plantago major* var. *scopulorum*.

Comparison of single species occurrences, using the Chi-square Test, revealed a highly significant reduction between the first and second transects for *Elodea*, *Alopecurus* and *Myriophyllum* spp. A significant difference was found in the lower occurrence of *Plagiobothrys*. The decrease in the amount of cover found on Study Site 3 from the first transect to the second was highly significant.

Comparison of Sites

Data for the first transect revealed some significant differences between the study sites, using a Chi-square Test to compare single species occurrences. Highly significant differences in the number of individuals of *Sparganium*, *Alopecurus*, *Distichlis*, *Hippuris*, *Taraxacum*, *Plagiobothrys*, *Glyceria*, *Agrostis*, "rushes", "aquatics", and unidentifiable grasses were found. Differences for *Typha*, *Beckmannia* and *Veronica* were found to be significant. Relative occurrence of *Arnica* and *Artemisia* were found not to be significant, probably owing to the small numbers involved.

Lower Plants

Mats of thermal blue-green algae covered the bottom of the hot springs channel for much of its length. Samples of this algae have been identified as being in the genera *Oscillatoria* and *Synechoccus*.

Though there was only a slight amount of rain during the summer, two species of mushrooms were found in the study area. *Agaricus* sp. was discovered on Study Site 1 among the salt grass, and several *Conocybe coprophila* were found on cow manure in a field east of Study Site 3.

Small Floating Aquatics

One species of aquatic liverwort, *Ricciocarpus natans* was found floating among the tules intermixed with Duckweed, *Lemna gibba* and Greater Duckweed, *Spirodela polyrhiza*. *Lemna* was most abundant followed by *Spirodela* then the relatively scarce *Ricciocarpus*. All were found in the channel included in Study Site 1 but on the south side of the road and also in the channel under the steel bridge.

Soil Moisture

Measurements of soil moisture showed readings of from 78 to 100% saturation at points one meter or less from a channel of water. At points three or more meters from a channel in salt grass, readings ranged from 58 to 100%. At points within the sagebrush scrub, readings ranged from 5 to 65%. Readings increased after rain and when water levels in nearby channels had increased.

Typha Observations

In a stand of 30 *Typha latifolia* plants, on July 13, 25 had spikes; 12 appeared successful and 13 were immature, withered and dried. In the same stand of 30 plants, on August 3, 27 had spikes; 8 appeared successful and 19 were

immature, withered and dried. Since a successful spike would not appear immature even if withered and dried, 4 of the 12 successful spikes observed on July 13 had disappeared, probably foraged by cattle that escaped the confines of the fence. Six more spikes had withered and dried. On August 21, it was noted that all plants in this stand had been foraged.

A count in another area comparing the numbers and success of the present season's (Summer, 1976) T. latifolia spikes with the number of stalks remaining from the previous season (N=100) showed 17 from the previous season and 83 from the present season. Of the 83 from the present season, only two were successful, the others having withered and dried before reaching maturity.

DISCUSSION

General

The vegetation analysis was designed to give a representation of the vegetation on the particular study sites, and is not an account of the average vegetation found over the entire Marble Hot Springs Study Area, or the individual habitats therein. However, the data for Study Site 2 is presented as an analysis of the composition of discrete vegetation zones.

The figures given for cover, taken from the first transect, represent basal area, not vegetative cover. This naturally contains an error factor, due to the different habits and sizes of the various species. Though two plants may have the same three-dimensional displacement, horizontal species would register more basal area coverage than erect species.

The ten-point frame vegetation analysis method was used to survey one 100 m long east-west transect line each on Study Sites 1 and 3, on July 26. This was done to compare the relative accuracy of the point intercept method. No significant differences for single species occurrence were detected using the Chi-square Test comparing the two methods. Only the data from July 26 was used in this comparison, to avoid including any element of time-related changes in vegetation.

Of the 146 species of flowering plants collected in the Marble Hot Springs Area, many were infrequent or of rare occurrence. The dominant species, which made up most of the plant cover, were less than a dozen.

Important plant associations mentioned previously were: Sagebrush Scrub Association, covering large expanses of the valley floor, dominated by Artemisia; Aquatic Plants floating in still waters, with Myriophyllum spp. and Elodea among others; Tule, Sedge and Rush Associations of marshy areas, composed mostly of Typha, Scirpus spp., Carex spp., Eleocharis spp. and Juncus spp.; and Salt Grass Association in which Distichlis covered large areas in solid stands containing few other grasses or forbs.

Directly and indirectly, agricultural practices have certainly been the cause of the influx of exotics. Tillage, irrigation, haying and livestock grazing have all contributed to the invasion of the valley's plant community.

A point of historical botanical interest along these lines might be added as to a major vegetational change which has occurred in Sierra Valley within the past 100 years, since its settling by the white man. It has been reported by Artie Strang, a 72-year resident of the valley who lives a few miles west of Sierraville, that at one time much of the valley was occupied by a type of wild rye bunch grass which we believe to be Elymus cinerarus, that grew "as tall as a man". It has largely disappeared from the valley and is now only found in

scattered patches. Its place has been usurped largely by sagebrush, Artemisia tridentata, and associates. Our assumption is that the disappearance of the bunchgrasses has been caused by overgrazing and cutting of hay. A third, possibly more important reason was related by the same source. According to him, agricultural practices, mostly cultivation of grains, had been the main cause for the disappearance of the wild rye. Tillage of the soil apparently wore it out in a relatively short time and it was abandoned to the invasion of sagebrush.

There are no trees growing in the Marble Hot Springs Area, although some shrubby Salix grow along Dyson Lane near the steel bridge. Male and female plants were found scattered in clumps along the road for several hundred meters.

That the vegetation was drastically affected by the drought was evident in the corresponding early blooming and drying of the marsh plants. The reduced amount of forage had the subsequent effect of visibly increasing grazing by cattle. Almost all accessible, palatable forage was heavily grazed. Plants of the marsh associations, which would have normally had little appeal as livestock food, were grazed heavily by the middle of July. The entire area had a close-cropped appearance. Several long time local residents whom we encountered in the area reported that they had not witnessed such heavy grazing upon the marsh plants in many years. Most certainly, this past year's drought will affect the quality of next year's wildlife habitat. Many two-meter tall stands of cattails and tules were reduced to below-waist height.

Roadside vegetation was also subjected to heavier than usual grazing this year, because the normally flooded ditches, which once acted to contain herds (year-round) dried up completely, allowing cattle onto the road. A flock of sheep was herded down Dyson Lane at least once during the summer, leaving their mark on the vegetation.

Most of the plants growing along the road were weeds: plants which were introduced from other places, mostly Europe. Many were aggressive weeds, which would usurp the native vegetation wherever it was disturbed. Some examples of invasive roadside weeds are: Circium vulgare, Lepidium spp., Rumex spp., Chenopodium spp., Taraxacum and others noted on the species list (Appendix I).

Water in some of the channels and ditches dried up before the middle of August, leaving no more than puddles in some of the lower places beneath bridges. This undoubtedly affected the flowering periods of the aquatic plants and other water-dependent species such as Typha and Scirpus spp. These plants flowered earlier and probably set less seed as a direct effect of the drought.

One specific instance which exemplifies the extremity of the drought, was the collection of depauperate specimens of Alisma trivale, water plaintain, a marsh plant which normally attains a height of 0.6-1.0 m. This year, those which we encountered were no taller than 15 cm. Additionally, Brodiaea was found occasionally but umbels were limp and scapes wilted. Only one normally flowering specimen in anthesis was found. Specimens of Chenopodium chenopodiodies were markedly depauperate.

Several plants were observed in the area, but not collected because none was found in flower. They were Ceanothus prostratus, along Dyson Lane just east of the steel bridge near Study Site 3; Juncus mexicanus, similar to but distinguished from J. balticus by the spiralling flattened stems, and Rosa sp. observed growing along the road between Study Sites 2 and 3.

Several plants were collected and identified by the SFSU "Sierra Valley Marsh Ecosystem" class (June, 1975) which were not collected by us. They are:

Downingia bella, Polygonum natans, Orthocarpus campestre, Allium anceps and Carex rostrata.

Study Site 1

The configuration of plant associations on Study Site 1 was clearly outlined by the presence of perennial water channels. The north-south channel was the dominant body of water on the site. It was essentially stagnant throughout the summer. Of much narrower, more irregular proportions, was the channel of Marble Hot Springs, which flowed into the main channel within the study site boundaries. Both maintained a fairly constant water level. The edges and banks of these channels were occupied by belts of rushes (Cyperaceae/Juncaceae) and cattails (Typha), restricted to the heavy, usually moist soil. East of the main channel, the marshy habitat extended well beyond the study site. To the west, marsh plants quickly gave way to a wide stretch of alkali flat covered by an almost pure stand of Distichlis, interspersed with a few other grasses and forbs. Some patches were bare due to cattle activity, and in other places, thick accumulations of salts reduced the density of plants. The salt flat contained many scattered mounds created by ant colonies. Some were still active ant hills. Extending onto the west edge of the site was a finger of Artemisia, an extension of the great expanse of sage which covered much of the valley floor.

Though most of the hot springs was too hot for any aquatic vegetation other than Cyanophytes, some flowering plants were found growing in contact with its water at its cooler extremities. These included, Scirpus americanus, Polypogon, Distichlis and Muhlenbergia.

Along the road on the south edge of the site ran a ditch containing a moderately dense cover of Eleocharis spp. and Juncus spp. Many of these plants, particularly those resembling J. mexicanus, failed to flower due to the effect of the drought. This ditch dried up thoroughly by mid-August, receding toward the main channel. Flowering of other plants on the site such as Typha, was also noticeably inhibited, probably owing to a shortage of water. In cattail stands which were high and dry, many spikes were curved rather than erect, and reduced in thickness.

Lack of water itself was not the only cause of growth retardation. Due to the lack or shortage of adequate forage, cattle grazed Typha, Scirpus spp. and other emergent aquatic marsh inhabitants and trampled otherwise dense stands.

Study Site 2

The transect data for Study Site 2 shows that there were significantly more Distichlis than any of the other plants (except Cyperaceae/Juncaceae) in June but not in August. This is probably due to the fact that much of the Distichlis had been dried, trampled and grazed so that it was identifiable only to family. The numbers of points at which plants of the family Gramineae occurred increased from 23 in June to 32 in August, while the number of Distichlis decreased from 44 in June to 30 in August.

Distichlis, unlike most of the plants of the Salt Flat Zone which occurred only in that zone, was found in the Marsh Zone as well. However, the few points at which Distichlis occurred in the Marsh Zone were at or near the transition between the two zones.

Study Site 3

The fact that the surface of Study Site 3 was covered 20% by water would

seem to indicate the physical conditions needed to support a wetlands vegetation type. While many of the plant species found on the study site were dependent on moist circumstances, many resembled, in their appearance a different, more arid type of association because of their condition. The barren appearance of the site and the surrounding area was due mostly to cattle trampling and grazing, which was most likely intensified by the early drought.

A comparison between the field in which Study Site 3 was situated and an adjacent field lying to the east showed some striking differences. This neighboring field was observed to have a physical situation similar to that found in the Study Site 3 field, but the two were separated by a fence. Their different owners obviously had very different management practices. No cattle grazing occurred on the eastern field until after it had been cut for hay, late in July. This field contained a greater diversity of marsh and alkali plants, including grasses, sedges and petaloid flowering perennials. The alkali areas in this field contained many interesting species not found by us anywhere else in the area. This field was, in fact, one of the most productive and diverse collection areas utilized. If we can assume that cattle grazing was a major cause of the degradation of the Study Site 3 field, we might be able to explain some other observations. The inability of the researcher to distinguish among the genera in the family Cyperaceae and between them and Juncus spp. in most cases may be attributed to the inability of the plants to reach maturity and blooming because of incessant grazing by cattle. This necessitated combining all of them under the category "rushes". The category "grasses" was used for the same reason and was due to the same cause. It may also be that the observed differences in floristic composition on the study site as compared with ungrazed areas has been due, at least in part, to the impact of the cattle on the land. Of the species encountered in the transect a significant number were invasive species, not native to the California region.

In examining the transect data, we found that there was a highly significant difference between the percent cover at the time of the first transect (42%) versus the second transect (18%). While increased drought later in the season could account for some cover reduction, this effect was most likely reinforced by the grazing.

The highly significant reduction of Alopecurus on the study site might be attributed to the increased dryness of the later period as well as to the prolonged cattle grazing. It is doubtful whether Alopecurus disappeared entirely from the study site as indicated by the data. It was probably not counted in identifiable condition (flowering).

The highly significant reduction in the occurrence of the aquatics Elodea and Myriophyllum spp. cannot be related to cattle grazing or drought, for the large channel on Study Site 3 remained full throughout the summer, a fact we found surprising. Their reduction was either a natural seasonal occurrence or, very probably, due to traffic crossing the channel. Cattle had been observed crossing the waterways in Study Site 3 and vicinity but not normally in the deeper water where the aquatics were common. A heavy impact was probably made upon the channel by the botanists and the ichthyologists in the collection of specimens. A significant reduction was also found for Plagiobothrys. Its reduction is believed to be part of a normal seasonal cycle.

Another interesting vegetative feature of Study Site 3 was the vernal pool type of flora, occupying the edges of depressions containing water seasonally.

Myriophyllum spp., Marsilea, Downingia, Veronica, Ranunculus, Flammula, Rorippa, Navarretia, Euphorbia and Eryngium were found at varying distances along the banks and in the water of these depressions. The maturity of these plants was observed to be roughly related to their distance from the water and their specific water requirements.

In summarizing the observations of Study Site 3, though the vegetational characteristics were most interesting, the condition of the plants was, for the most part, very poor, and the range in general, greatly disturbed.

Soil Moisture

Since the prongs of the soil moisture indicator tended to become loose when pushed into hard, dry ground, these measurements may not be reliable.

Typha Observations

The count comparing the numbers and success of the present season's *Typha latifolia* spikes with the number of stalks remaining from the previous year may indicate that the number of *T. latifolia* spikes this season was not fewer than that of the previous year. This conclusion is limited by the amount of data and by the fact that counting the previous year's spike stalks as an indication of the number of spikes produced that year assumes that few have been trampled, decayed or carried away, and that all old stalks are last year's and not those of previous years. Although there may have been more *T. latifolia* spikes produced this year, only 2 of the 83 produced did not wither and dry before maturing. However, this scarcity of maturing spikes may have little effect on the numbers of *T. latifolia* as the plant progagates itself by sending out rhizomes as well as by seed dispersal. Some new *T. latifolia* shoots were noticed in August indicating that vegetative reproduction was beginning after the intense grazing.

SUMMARY

The important plant associations found in the study area were: Sagebrush Scrub, Aquatic Plants floating in the water, Tule, Sedge and Rush in the marshy areas and Salt Grass on the alkaline saltflats. Plants collected numbered 146 species from 43 families. Vegetation analysis made by point intercept line transects showed the dominant plants to be, in Study Sites 1 and 2, *Distichlis spicata*, and in Study Sites 2 and 3, plants of the families Cyperaceae and Juncaceae, including *Eleocharis* spp., *Juncus* spp., *Carex* spp., and *Scirpus americanus*. In Study Sites 1 and 3, aquatic plants were also found to be relatively dominant; they were: in Study Site 1, *Potamogeton pectinatus* and in Study Site 3, *Elodea* and *Myriophyllum* spp.

Photographs were taken to record changes in vegetation and fluctuations in water level which overall decreased markedly during the course of the summer. The portion of the Study Site 2 surface covered by water three or more inches in depth decreased from 73% in late June to none in August. The early blooming and subsequent drying of the marsh plants was indicative of the effect of the drought on the vegetation. In Study Sites 1 and 3, the plant cover, especially aquatic plants, decreased significantly between June and August. In Study Site 2, the cover did not change significantly, however the plants decreased drastically in height. Observations of flowering in *Typha latifolia* showed the majority of spikes to be unsuccessful, withering and drying before reaching maturity. Reduced amounts of the usual forage plants caused increased grazing of marsh plants.

CHAPTER 4
ARTHROPODS

INTRODUCTION

The endeavor to gather baseline information on the arthropods of the Marble Hot Springs Study Area (MHSSA) has had two emphases. The principal effort was given to compiling as comprehensive a species survey as time and equipment allowed. The result of this, to date, is Appendix II, a compendium of the arthropod (and some other invertebrate) taxa represented in the collection of invertebrates made by the three of us in the summer and fall of 1976. The arthropods listed here (with the exception of the mayflies) were identified to family using Borror and DeLong (1971). Usinger (1956) was used for determinations below the family level (including mayflies). Specialists who have helped, or are in the process of helping, with the determinations of specific groups of invertebrates are also listed in Appendix II. Representative collections will be filed in the Entomology Museum at San Francisco State University and at the California Academy of Sciences, San Francisco.

Secondly, the collecting regimen was designed to provide clues as to habitat preference, spatial distribution patterns, and temporal changes in abundance for as many arthropod populations as possible. Of the five realms of investigation, three are discussed here: aquatics, flight trap catches, and pitfall catches. The collections from specific vegetation types and nocturnal sampling have not yet been analyzed.

METHODS

Aquatics

Light Traps

Aquatic light-baited interception traps (ALT) were made with a two-pound coffee can held partly submerged, with the open end directed 45° below the water surface, by a metal-framed styrofoam float. The float also held batteries which operated a light bulb located in the upper end of the can. An inverted funnel placed in the open end of the can allowed insects to swim into but probably not out of the trap. In water with a noticeable current, the trap openings faced downstream to attract insects which might orient against the current. Each trap set on 10 June utilized two 1.5 v "D" cell mercury batteries wired in series (those of 17 June were wired in parallel) to power a Calelectro No. E2-474 bulb. Subsequent traps were powered by Eveready 1.2 v "D" cell, nickel-cadmium batteries wired in parallel. These were recharged for 14 hours prior to each use. The bulbs were replaced as needed.

ALT's were periodically placed at four permanent localities within Study Sites 1 and 2 (SS1 and SS2)(Figures 2.01, 4.01 and 4.02), and haphazardly in Study Site 3 (SS3)(Figure 4.03). Traps were collected on the mornings of 10 and 17 June and 1, 15 and 29 July, after having been set the previous evenings. In SS1, on 29 July, only the catches of ALT's No. 2 and No. 3 were recorded, as the catches of the other two were lost; thus the total trap effort in this site was 18 trap-nights. In SS2 the trapping effort was reduced, and finally stopped, as the permanent locales dried out: Four traps were collected on 10 June, two (Nos. 3 and 4) on 17 June, and one (No. 4) on 1 July. The

Fig. 4.01. Map of Study Site 1 showing locations of arthropod traps, MHSSA, Sierra Valley, CA, 1976. (Refer to Fig. 3.02 for vegetation legend.)

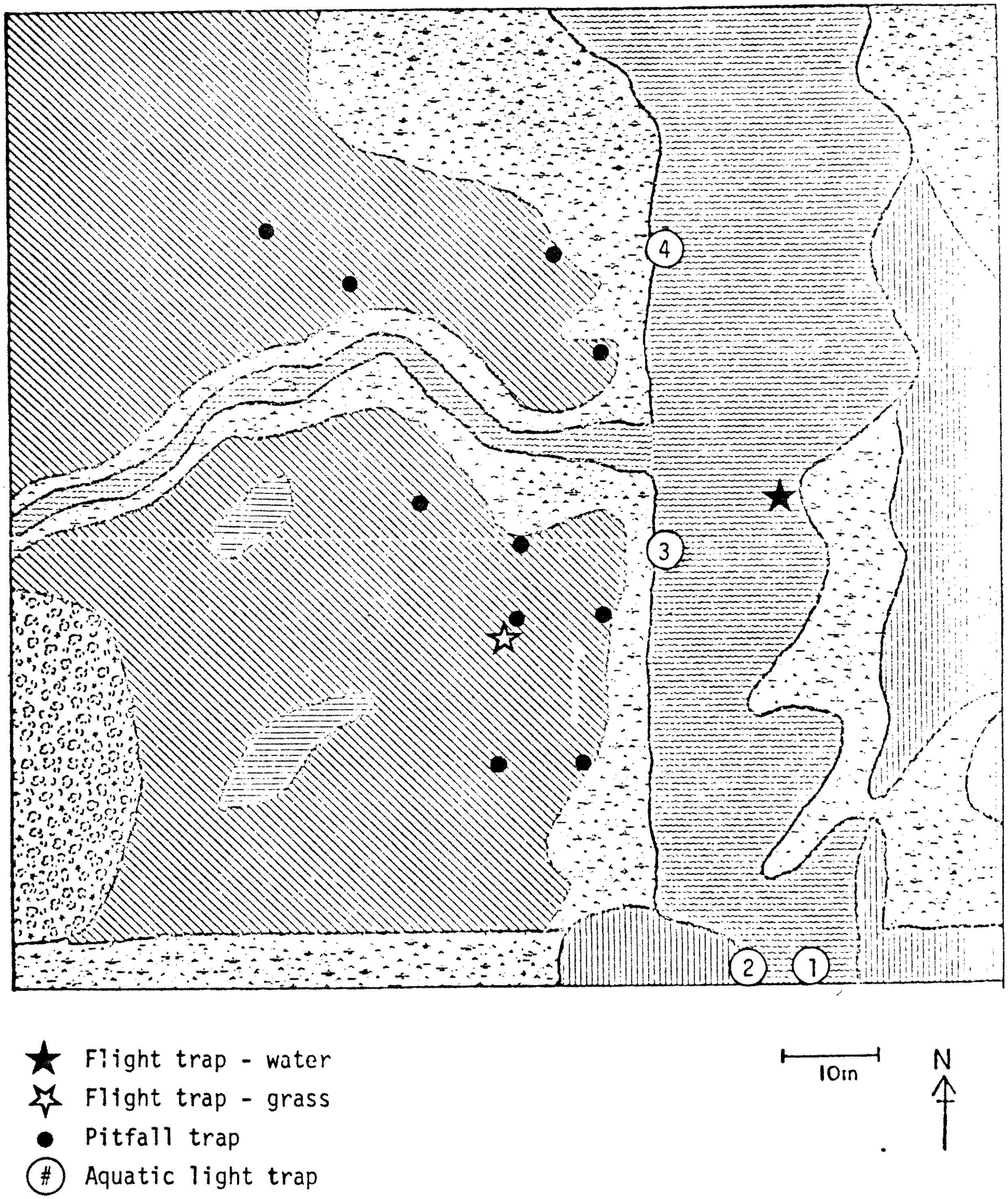


Fig. 4.02. Map of Study Site 2 showing locations of arthropod traps, MHSSA, Sierra Valley, CA, 1976. (Refer to Fig. 3.03 for vegetation legend.)

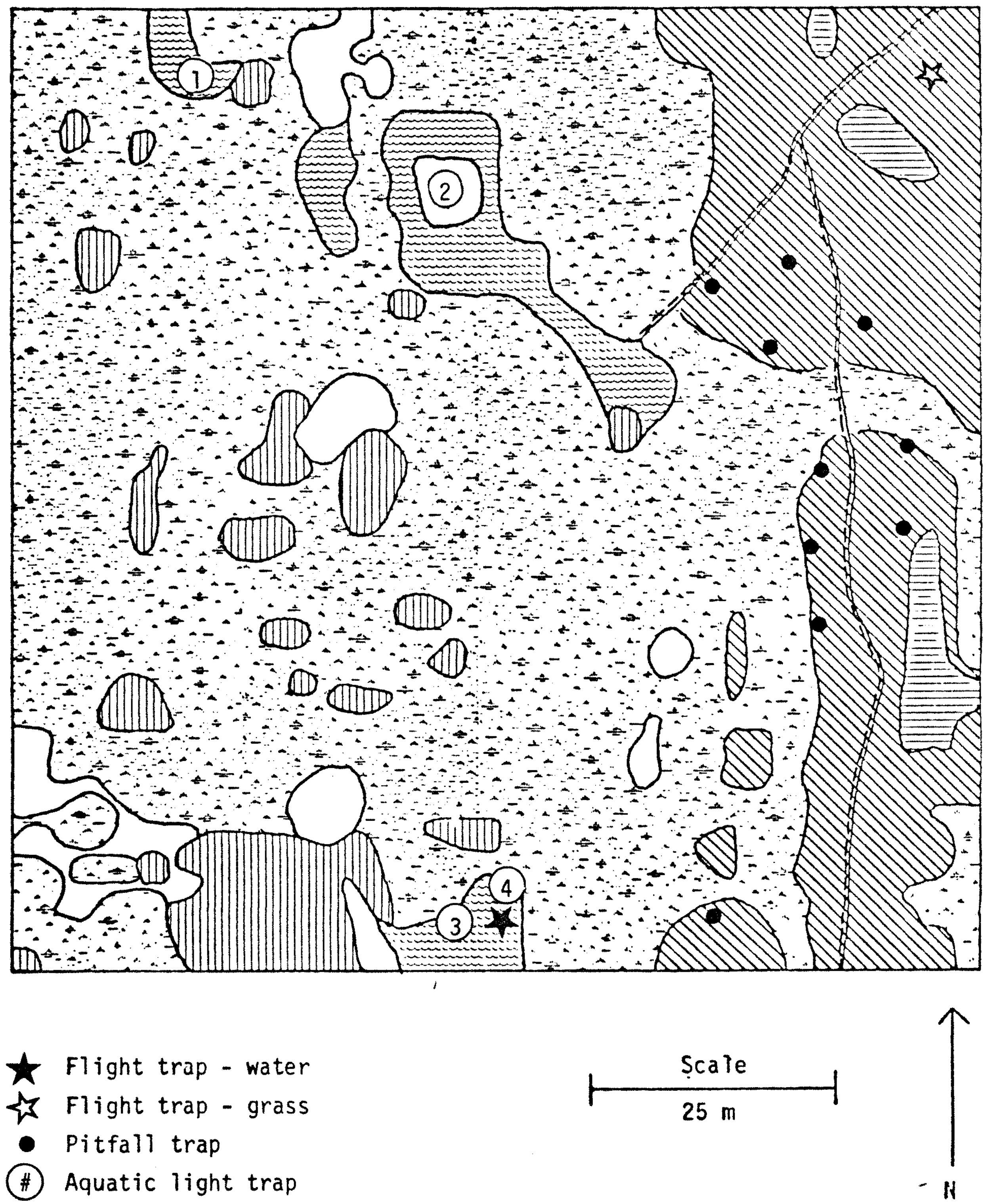
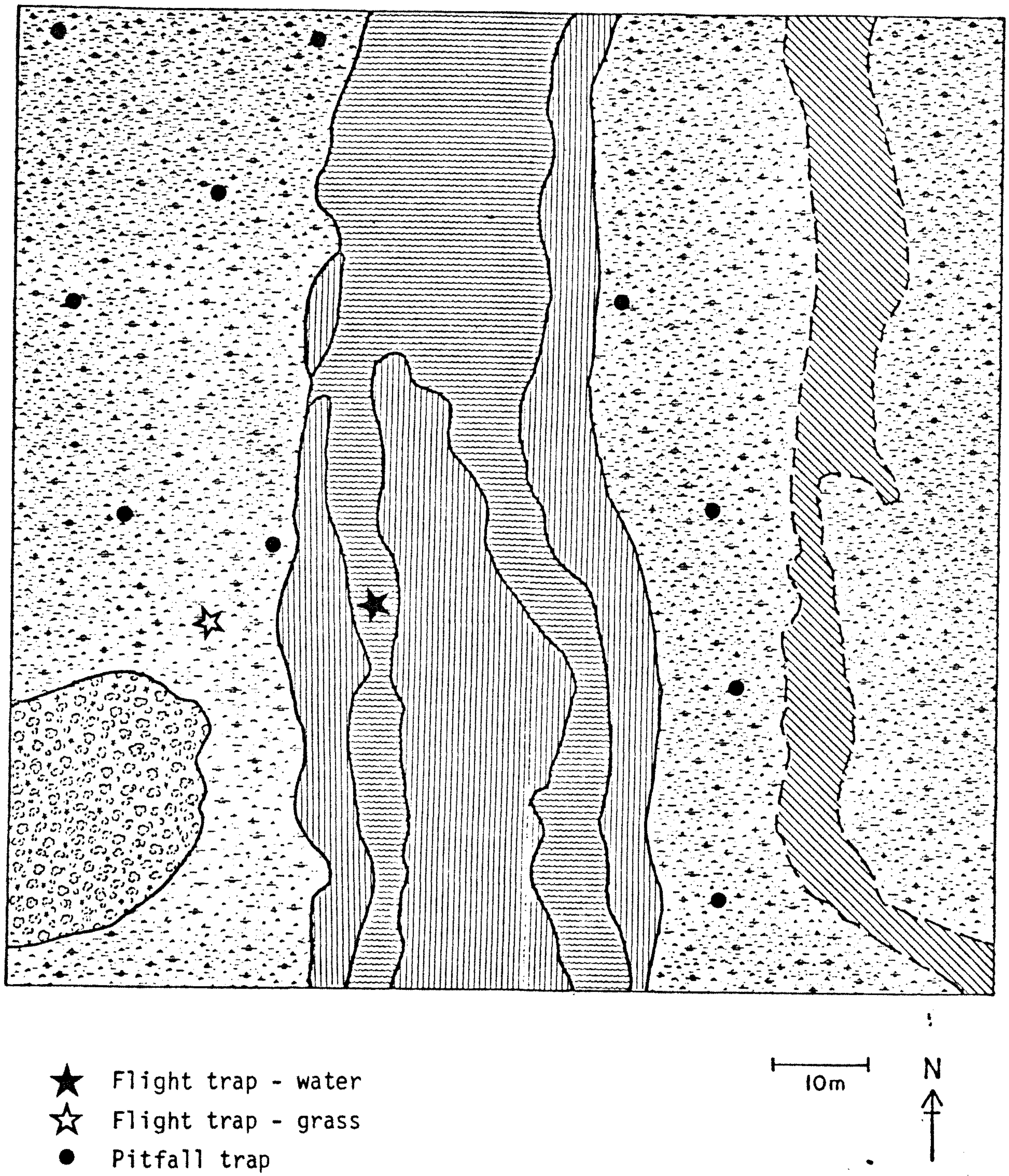


Fig. 4.03. Map of Study Site 3 showing locations of arthropod traps, MHSSA, Sierra Valley, CA, 1976. (Refer to Fig. 3.04 for vegetation legend.)



total trap effort in SS3 was 20. On 15 August four traps were set in the pond between Study Areas 1 and 2 (A1-A2 Pool, Figure 2.01), and collected the following morning. (Study Areas 1, 2 and 3 are the areas surrounding Study Sites 1, 2 and 3, respectively.)

Dip Nets

Eight-inch, triangular, aquatic dip nets (DIP) were used for general and systematic sampling of microhabitats. Systematic sampling consisted of collecting all of the invertebrates caught in each net sample. Over 30 systematic samples were taken during the study period throughout the MHSSA; additional samples were taken in mid-month of September, October and November. The sampling effort was limited during the first half of the summer to avoid trampling marsh vegetation and disrupting nesting birds, and during the second half by the widespread shift from marsh to cow pasture which resulted from the decline of surface water and subsequent invasion of grazing cattle.

Night Lights

Night light sampling (NL) was done twice monthly from sundown until approximately 2400 hours; ultra-violet and white light were reflected off a sheet toward a marshy area. Insects attracted to the sheet were collected at half-hour intervals. These catches have not yet been evaluated; however, most of the aquatic individuals (adults which primarily utilize the aquatic environment) have been separated out. They, and aquatic forms collected in flight traps and pitfall traps have been included in the Results and Discussion.

Flight Traps

Flying insects were sampled with flight traps in order to provide a method of systematic collecting which could be used for monitoring population fluctuations of selected groups throughout the summer.

The flight trap consists of four vertical net panels 138 cm high and 97 cm wide at the base, and tapering to a width of 21 cm at the top. This is partially covered by a net canopy extending 83 cm down from a collecting can set in a 12.2 cm diameter aluminum ring. The canopy overlaps the net panels by 28 cm. The netting is held within a four-legged fiberglass frame which attaches to the aluminum ring. Insects fly onto the panels and move upward, eventually entering a collecting can through an inverted funnel which prevents their escape. A small piece of Shell No-Pest Strip within the can immobilizes them. The trap can be floated on water when a styrofoam platform is attached to the base of each leg.

The traps were set (Mondays on saltgrass, Wednesdays on water) at prescribed locations in each study site (Figures 4.01, 4.02 and 4.03) every other week from 14 June through 11 August, 1976. Three two-hour collection periods were sampled each trapping day; the first beginning one-half hour after sunrise, the second from 12:00 to 2:00 p.m. PDT, and the third beginning one hour and forty-five minutes before sunset. Collections were made from the traps by aspirating all insects off of the net panels and removing all insects from the can.

Pitfall Traps

Pitfall traps were used to sample ground-dwelling and ground-frequenting arthropods throughout the summer. In each of the three study sites, 10 pitfall

traps, number 10 cans sunk in the ground and covered with slightly raised 9 by 9 in. masonite lids, were set in salt grass near water, no less than 10 paces apart (Figures 4.01, 4.02 and 4.03). Although these are essentially interception traps, the lids may serve as a "bait" for those animals seeking shelter. Ethylene glycol in each can prevented predation by killing the animals which fell into the trap. Arthropods were collected from the pitfalls with aquarium nets each Monday and Thursday morning from 17 June to 26 August 1976. For each individual caught, the study site, pitfall number and date of collection were recorded.

RESULTS AND DISCUSSION

Aquatics

The overall success of the ALT's, as judged by the number of traps whose lights were still on at the time of retrieval, was less than 50%. The complete success of the last trapping effort (16 August) was probably due to the fact that after the rechargeable batteries were used several times they were finally able to take enough charge to operate the bulbs for at least 12 hours. Wiring the batteries in parallel increased the life of the bulbs. Because of the error introduced by the operational problem of the ALT's, no statistical method has been used to find significance in variation of insect numbers between traps, study sites or trapping days.

The catch per unit effort of ALT's whose lights remained on shows a difference in insect abundance between the three sites. The highest catch per unit effort was 33 in SS2. To some extent this value reflects the increasing insect densities as the water dried up. SS3 had the lowest catch per unit effort (10) despite having over 50% success with lights. SS1, excluding 331 corixid naiads from Trap No. 4 on 1 July, had 29. The average catches obtained considering all of the light traps hold roughly the same relative proportions between study sites, althouth the figures are slightly depressed. The insect catch per unit effort in A1-A2 Pool (excluding the very abundant corixid naiads) was 24. The insect numbers per trap ranged from 17 to 57 in SS1, 6 to 60 in SS2, 0 to 44 in SS3 and 7 to 46 in A1-A2 Pool.

Excluding Diptera, at least 30 species of aquatic insects were represented in the ALT catches: 28 in SS1, 13 in SS2 and 20 in SS3. The depressed value for SS2 is most likely due to the limited trapping effort. An additional five species, which occurred in the ALT's of the other sites, were found in SS2 in dip net samples.

Overall, aquatic sampling yielded about 6500 specimens, representing at least 86 species in 35 families. Almost half (46%) of the collection are insects. A discussion of specific taxa follows.

Annotated Species List

Although no specific attempt was made to collect invertebrates other than arthropods, such individuals occasionally appeared in the collection. One clam (Mollusca) was taken in a dip net sample from SS1 on 9 August. Snails, representing at least six genera, were collected in all three areas throughout the summer. Twenty-eight leeches (Annelida: Hirudinea), of at least three species, were taken in Areas 1 and 2: almost 90% were collected in aquatic light traps, all but one of which had been set in SS2 in June.

Despite their sporadic appearance in the collection, cladocerans, most likely of the genus Daphnia, (Crustacea: Cladocera) were the most numerous of all aquatic arthropods collected. Of the 2357 caught, 2021 were taken from four aquatic light traps set in A1-A2 Pool on 16 August, and of those, 81% were caught in a single trap. One hundred and ten of the 115 copepods (Crustacea: Brachiopoda) in the collection were taken from a single aquatic light trap in SS1 on 29 July. Five more were picked up in two light traps in A1-A2 Pool on 16 August.

Amphipods (Crustacea: Amphipoda) appeared in dip net and aquatic light trap samples in all three sites throughout the study period. They represent at least one species, Hyalella azteca Saussure.

Water mites were found in all areas and throughout the summer. Ninety percent were collected in aquatic light traps in SS1. Some lived in the warm water flowing from the hot spring. At least two species are represented in the collection.

Ephemeroptera

Of the 732 naiads of Baetidae collected throughout the summer, 12 belong to Caenis, while six are unidentified. The remainder are in the genus Callibaetis. They were found in all areas, including the hot creeks where several were found in October and November. The data allow no correlation of the naiads to any specific vegetation type. They apparently had a highly clumped distribution pattern as less than 10% of the samples contributed more than 74% of the collection.

Only 23% of the naiads were collected in aquatic light traps. In SS1, Trap No. 4, located just downstream of the hot creek outflow, collected most of the naiads. Almost four-fifths of those from SS1 were caught on July 1.

Callibaetis, restricted to quiet waters, are termed as climbers (Needham, et al, 1935) and are generally found in hydrophytic vegetation. The nymphs of Caenis were not caught often, however the bottom silt of depositing zones of a waterway—the habitat of Caenis (Eastham, 1938)—unfortunately was not sampled.

Odonata

Two hundred and fifteen immature odonates, representing four families, were collected during the study period. Taxonomic work on all specimens is currently being done by R.W. Garrison of U.C. Berkeley.

Eighteen naiads of the family Aeshnidae were caught in dip net samples in the channel running north from SS1 into Area 2 in areas of marsh vegetation and in unspecified localities in Area 3. Aeshnids appeared in the samples from 30 June through the end of the study.

The Libellulidae were represented by 29 naiads collected throughout the summer. They were found in each study site as well as in the hot creek south of Dyson Lane. As with the aeshnids, no libellulid was caught in an aquatic light trap. It is suspected that, once taxonomic work is completed, different species will show different habitat preferences and activity periods.

Fifty-eight naiads of the genus Lestes (Lestidae) were collected in SS1 and SS2 from the beginning of the study until mid-July; one was found in Area 3 in late June. One-fifth were caught in aquatic light traps (22 in SS2), the remainder in dip net samples of shallow water in vegetated areas. Lestes is normally found in ephemeral ponds and has adapted to this by having a short life

cycle (Lutz, 1948). Its eggs are placed on vegetation above the water level, where they might have been affected by the unusually heavy grazing by the cattle in this area.

One hundred and ten naiads of Coenagrionidae were collected throughout the summer. They were found in all areas sampled, including both hot creeks. Almost one-third were caught in aquatic light traps (21 in SS1, 1 in SS2 and 3 in SS3). It is suspected that Enallagma and Ischnura are the dominant genera. The naiads, especially zygopterans, are an important protein source for ducks, especially during breeding time (Krull, 1970).

Hemiptera

The aquatic insects collected in the greatest numbers (over a thousand) belong to the family Corixidae. Four species are represented in the summer collection: 102 specimens of Corisella decolor Uhler, 84 of Callicorixa audeni Hungerford, 77 of Sigara omani (Hungerford), and 52 of Hesperocorixa laevigata (Uhler). Additional specimens of each species except H. laevigata were collected in the autumn. At least one individual of each (18 of C. decolor) was collected from a hot creek. Two specimens of Cenocorixa wileyae (Hungerford) were found in a ditch north of SS2 on 20 November. Most corixids were caught in aquatic light traps. Those that were not were found in areas of Typha, Hippuris, sedges and algae. Accumulated light trap catches yielded roughly equal numbers of males and females in each species, with the exception of C. decolor where twice as many males as females were found. Naiads outnumbered adults by more than two to one, but no naiads were found in either hot creek.

The total numbers of each species and naiads collected in aquatic light traps in four locations are shown in Table 4.01. Specimens of Corisella decolor dominated the catches of each location except SS2. These were caught throughout the summer as well as on each trap day. In SS1 each trap caught at least one individual, although over two-thirds were collected from Trap No. 4, located just downstream from the hot creek outflow. Callicorixa audeni, also found throughout the summer, was the only species collected in the aquatic light traps of each location. It was the most frequently encountered species in SS2. More than half of the specimens of this species collected in SS1 came from Trap No. 2, which was adjacent to a patch of Typha. Sigara omani, although encountered throughout the summer, ceased appearing in aquatic light traps after July 15. Like C. audeni, over half of the specimens from SS1 were taken from Trap No. 2. Hesperocorixa laevigata did not appear in aquatic light traps until 15 July. This may account for their absence in SS2, where all trace of surface water had vanished by 12 July. Almost half of the specimens collected in SS1 were from Trap No. 4.

Table 4.01. Total species composition of corixids in four locations as shown by aquatic light trap catches, MHSSA, 1976.

Site	Corisella decolor	Callicorixa audeni	Sigara omani	Hesperocorixa laevigata	Naiads
SS1	38	16	10	21	403
SS2	0	52	16	0	35
SS3	12	1	7	5	2
A1-A2 Pool	15	6	0	11	160

Corixid naiads were found throughout the summer and in all locations; 331 (representing several instars) of those caught in SS1 were taken from Trap No. 4 on 1 July; 80% of those not from Trap No. 4 were from Trap No. 2, almost half of which were collected on July 29.

Corixids are primarily herbivores, although a large part of the diet is debris. Waterboatmen occupy an exceptionally important niche in the food web, being an important item of food for aquatic animals (Borror and DeLong, 1971). Also various species have marked preferences for particular habitats and thus may serve as indicators of local conditions (Usinger, 1956).

Thirty-two adults of three species of Notonecta (Notonectidae) were collected during the study. A single specimen of N. undulata Say was found in Area 3 on 29 July. A second one was caught the following October. Members of N. unifasciata Guerin, representing a little over half of the notonectid collection, were collected in all study sites, although half were taken from the hot creek south of Dyson Lane in mid-August. (An additional specimen was taken from that creek on 17 September.) The data suggest that they were active throughout the summer. The remaining specimens belong to N. spinosa Hungerford. These were also found in each study site and were apparently active throughout the summer. Notonectid naiads outnumbered adults in the collection by two to one. Almost half were collected in aquatic light traps, whereas only four adults were caught with this method. Like the adults, they were found in all study sites, and were active throughout the summer. Two naiads were taken from the hot creed south of Dyson Lane on 20 August. Backswimmers are predaceous and occasionally feed on small fish but also feed on chironomid and mosquito larvae.

Belostoma bakeri Montd. (Belostomidae) is represented in the collection by one specimen found in Area 3 on 28 June and two from the hot creek south of Dyson Lane on 20 August. (Three more were found in the hot creek in mid-October.) Six adults of Lethocerus americanus Leidy were collected from near a white-ultraviolet light set near Area 2 on the night of 16 June. On that same night an adult was caught in an aquatic light trap in SS1. One belostomatid naiad was caught in the hot creek north of Dyson Lane on 7 June, one in SS2 on 30 June, two in pitfall traps in SS2 on 1 July and three in the hotcreek south of Dyson Lane on 20 August. Giant water bugs are predaceous, feeding on aquatic organisms such as tadpoles and small fishes, and can be a problem in fish hatcheries.

Ranatra (Nepidae) is represented in the collection by four adults collected in aquatic light traps in SS1 on 15 July, one adult from north of Area 2 on 28 June, two adults from under the steel bridge on 19 July, three adults from Area 3 at different times during the study. Water scorpions are predaceous on aquatic invertebrates. They can be found in trash and mud (Pennak, 1953), and dense aquatic vegetation (Usinger, 1956).

One specimen of Gelastocoris (Gelastocoridae) was collected from a mud bank in Area 3 on 19 July.

Twenty-one adults and eight naiads of the femily Gerridae were found sporadically during the study period. Specimens of Gerris incognitus Drake and Hottes were found in SS1 in June and August, and, along with those of G. incurvatus Drake and Hottes, in Area 3 in June and July. Two specimens of each were

taken from the hot creek south of Dyson Lane in mid-August. Naiads were taken from SS1 and Area 3 in June and August. The populations of gerrids were never great. Their numbers could have been reduced when the water dried, as suggested by Borror and DeLong (1971). Water striders feed upon entomostracans and aquatic insects which they catch just below the surface and upon terrestrial insects which fall upon the water surface (Pennak, 1953).

Diptera

Of the four species of mosquitos (Culicidae) in the summer collection (see Appendix II), only two are represented by larvae. One specimen of *Anopheles freeborni* Aitken was caught in an aquatic light trap in SS2 on 17 June, one was found on the north edge of SS2 on 30 June, and five were taken from the drying channel west of SS2 on 14 July. Six specimens of *Culex tarsalis* Coquillett were taken in the same catch as *A. freeborni* on 14 July; one was found near there on 11 August, and one was taken from the hot creek south of Dyson Lane in mid-October. In the past the mosquito population has been termed as mild to high by local residents, whereas this summer it was almost nonexistent. One speculation is that due to the mild winter, the population peaked early, before our field work began.

Larvae of the genus *Dixa* (Dixidae) were collected from areas of *Hippuris*, sedges and rushes. Four were taken from SS2 in late June and two more in mid-August.

Aquatic sampling yielded 182 specimens of the family Chironomidae. Although identification of these larval specimens below a family level has not been made, at least 38 species of adults were collected in the MHSSA (Appendix II). Of the 100 specimens taken in ALT's, 86 were from SS1 and 14 from SS3. While present throughout the trapping period, 60% were caught on 1 July. The ALT's collected larvae, pupae and newly emerged adults. In both SS1 and SS3, most specimens (96%) taken on 10 and 17 June were adults or pupae. In July, nearly two-thirds of the specimens were larvae. This cycle corresponds to the chironomid emergence encountered at the UV light on the evening of 16 June (see Flight Traps). The remaining specimens were taken by aquatic nets throughout the summer from all study sites and the hot creeks.

Two genera of the family Stratiomyidae were collected in the north hot springs creek. Larvae of both *Stratiomys* and *Hedriodiscus* were taken on 11 August.

Trichoptera

Caddis flies (Trichoptera) were represented by at least two families. A vegetative case was found in all study areas, and one composed of coarse sand was collected from Area 3. These cases seldom contained larvae or pupae. Adult specimens collected with aerial nets and at the UV light have not yet been analyzed.

Coleoptera

Forty species of aquatic beetles (Coleoptera) were represented by the more than 550 specimens collected from the MHSSA. Of seven families represented, the Dytiscidae and Hydrophilidae accounted for about 90% of the beetle collection. The other families were Haliplidae, Gyrinidae, Hydraenidae, Chrysomelidae and Curculionidae.

On 12 July a large number of dead insects were noticed as they were carried by the current of the north Marble Hot Springs Creek (No. MHS Cr.). Five minutes of collecting from one place in the creek yielded 83 insects, 72 of which were water beetles, the rest corixids. The beetles consisted of one specimen of Ochthebius rectus LeConte (Hydraenidae), 15 specimens of the family Dytiscidae, and 56 of the Hydrophilidae. Dytiscids consisted of four Hygrotus impressopunctatus (Schaller), two H. ?nigrescens Fall, six H. ?lutescens LeConte, one Liodessus affinis Say, and two Hydroporus sp. All species except Hydroporus were collected at other times during the study. Hydrophilids were represented by 18 specimens of Tropisternus lateralis (Fabricius), five of T. columbianus Brown, 32 of Enochrus conjunctus Fall, and one of Paracymus subcupreus (Say).

Forty-one specimens of Peltodytes callosus (LeConte)(Haliplidae) were collected. Twenty-one were taken by ALT's set in SS1, SS2 and the A1-A2 Pool. The remaining specimens were taken from all study areas in aquatic net samples of a variety of habitats including Typha and Hippuris. While present throughout the study, they were most frequently collected in August.

The predaceous diving beetles (Dytiscidae) were the most frequently encountered aquatic beetles of the MHSSA. The family was represented by 39 larvae and 251 adult specimens from 20 species. Species which were infrequently encountered and are not discussed are included in Appendix II.

Four species of Hygrotus were collected. The 109 specimens of H. ?lutescens represented more than 40% of all dytiscid adults and 80% of the genus. ALT's caught 19 specimens in SS1, 8 in SS3 and 6 in the A1-A2 Pool. Aquatic net samples reflected trapping results as additional specimens were taken from Area 1 and Area 3 but not Area 2. In Area 1 specimens were found in a variety of microhabitats including Typha, Hippuris, and algae, and in the No. MHS Cr. Specimens were collected throughout the summer but appeared more frequently in the latter half of July and August. Other specimens of Hygrotus appearing in the collection were 17 H. impressopunctatus, three H. tumidiventris, and seven H. ?nigrescens. ALT's in SS1 sampled all of these species, but those in SS3 only caught H. impressopunctatus. H. tumidiventris was collected only from SS1 and a ditch north of Area 2 in mid-June and early July, while SS1 and Area 3 yielded specimens of H. impressopunctatus throughout the summer and H. ?nigrescens in mid-July and late August. The six larvae identified to the Hygrotus/Hydroporus group were found in all areas including SS2 and the No. MHS Cr. throughout the summer.

Fifty-two specimens of Liodessus affinis were collected; of 32 taken by ALT's, 30 were from SS1 and two from SS3. Although specimens were trapped throughout June and July in SS1, the majority (23) were taken on 15 July as were both specimens from SS3. Aquatic net samples recorded this species in the south Marble Hot Springs Creek (So. MHS Cr.) in late August and its sporadic occurrence in all study areas throughout the summer.

The genus Rhantus was represented by three species. R. gutticollis Say was collected from No. MHS Cr. in October along with R. binotatus (Harris). In August, R. consimilis Mots. was taken from So. MHS Cr., Area 1 and Area 3. Colymbetes sculptilis Harris was also found in So. MHS Cr. in August and October. Additional specimens were collected in June by aquatic net in SS1 and PFT in SS2. All nine larvae of the Rhantus/Colymbetes group were collected

from Area 2. Their presence was recorded from mid-June through mid-August in ALT's and aquatic net samples of Hippuris and sedges.

Three specimens of Laccophilus mexicanus atristernalis Crotch were collected from the No. MHS Cr. in June and the So. MHS Cr. in October. Eleven specimens of L. maculosus decipiens LeConte were collected during June, July and October. Four were taken in SS1 ALT's and the remaining by aquatic net samples in Area 3 and in Typha of Area 1. Nine Laccophilus larvae were collected throughout the study period. Four were taken by ALT's in SS1 and SS3, the remainder by aquatic net from No. MHS Cr., the A1-A2 Pool and Area 3.

Of 15 specimens of Coptotomus longulus LeConte collected throughout the study period in Area 3, only one was collected by ALT. In August, three more specimens were taken from an area of Typha in Area 1. Six specimens of Ilybius fraterculus LeConte were collected during July and August in Area 3 and from an area of Typha in the A1-A2 Pool and Area 2. On 28 July four more specimens were caught at the UV light in Area 2.

Two specimens of Gyrinis consobrinus LeConte (Gyrinidae) were collected on 28 June in south Area 3. Eggs of gyrinids are known to be laid in spring on submerged vegetation. The abnormal reduction of water and the drying of pools may have affected the eggs of this family and the fluctuating water level in late summer may have affected the pupae, which are attached a little above the water line and are subject to drowning at this stage if inundated.

Three specimens of Ochthebius rectus LeConte (Hydraenidae) and four of O. lineatus LeConte were collected in the aquatic environment. They were taken in aquatic net samples from SS1, Areas 2 and 3 and the No. MHS Cr. An additional seven specimens of O. rectus were collected by PFT's in SS2 and two in FTG in SS1 during June.

Two hundred and two adult and 23 larval specimens, representing 13 species of water scavenger beetles (Hydrophilidae) were collected from the MHSSA. The genus Tropisternus was represented by two species. T. lateralis comprised about one-third of the total adult hydrophilids, and more than 80% of the genus. Only 14 specimens of T. columbianus were found. Both species were collected by ALT's in SS1 and SS2, but only T. lateralis was found in SS3 traps. Aquatic net samples also failed to establish the presence of T. columbianus in Area 3. Twenty-four specimens of T. lateralis were taken by ALT's. Almost half were from SS2 in spite of the reduced trapping effort. This may have been a reflection of increasing density due to decreasing water levels. The remainder occurred sporadically in SS1 and SS3 traps. Aquatic net sampling in all study areas, which included collections from Hippuris, Typha and algae, yielded an additional 26 specimens. Only five specimens of T. columbianus were taken by dip net and four of these were found in the hot creeks during June and October. Tropisternus larvae were found during June and July in all study areas using both collection methods.

Nine specimens of Enochrus conjunctus were collected, in addition to the 32 found in the No. MHS Cr. These were taken throughout the summer by aquatic net samples made in all study areas, and in PFT's in SS1 during July. E. Obtusiusculus (Mots.) was also taken from a SS1 PFT in August and from sedges and algae of the So. MHS Cr. in October.

Twelve specimens of Paracymus subcupreus were collected. They were taken throughout the summer in aquatic net samples made in Area 3, SS2, a ditch north of Area 2, and So. MHS Cr. They were also taken from SS1 in a PFT and

FTW.

The 39 specimens of Helophorus, though not yet identified, represent at least three species. Samples made throughout the summer in unspecified locales in Area 3 yielded 27 specimens. Samples made in areas of Hippuris in both Areas 1 and 2 on 11 August yielded six specimens. Six more specimens were taken from the hot creeks in August and September.

Two aquatic species were collected only by non-aquatic methods. Numerous specimens of Hydrophilis triangularis Say were attracted to the ultraviolet light set along the roadside at Area 2 on 16 June and 28 July. Also collected at the UV light on 28 July were two specimens of Hydrobius fuscipes (Linneaus). Another specimen was collected from a SS2 PFT on 24 June.

The family Chrysomelidae was represented by two species. The entire life cycle of Galerucella numphaeae Linneaus was collected from the water lily Nuphar polysepalum Engelm., which grew in the Area 3 channel. Adults of Donacia, whose larvae are aquatic, were collected from Area 3.

Several species of the family Curculionidae were represented in the aquatic net sampling. Endalis ovalis LeConte was found in an area of sedges of SS2 in early June. Other specimens, whose occurrence in water may have been accidental, have not yet been identified.

Flight Traps

Flight trap analysis at this time has focused on two groups of flies (Diptera). These are three species of Dolichopodidae (Dolichopus amnicola Melander and Brues, D. idahoensis Aldrich, and D. nigricauda Van Duzee), and specimens of the family Chironomidae. Chironomids (midges) and dolichopodids (long-legged flies) were selected because of their relative ease in identification and seemingly adequate representation in the flight trap collections of each study site. For this study, chironomids have been analyzed as a family group, although we know they are represented by a minimum of 38 species (Appendix II).

The analysis attempted to a) assess seasonal activity of the taxa for the period of the study, b) determine a daily activity period, and c) distinguish population differences between the three study sites. Analysis utilized random block design/analysis of variance (RBD/AV) and when appropriate, Keul's multiple range test (MR).

Chironomidae

Morning flight trap collections of chironomids are compared between the three study sites for grassland and water habitats in Figure 4.04, A and B. Significant differences between the five collection days appear in both grassland and water (F = 5.84* and 7.95**, respectively). Only one catch in each habitat was isolated by MR as outstanding from the others, these being 28 June (grassland) and 16 June (water).

Chironomid activity during the noon trapping period for each habitat is shown in Figure 4.05, A and B. Midges in grass and water habitats demonstrated a significant change in seasonal activity (F = 6.89* and 7.12**). Again MR found only one catch in each habitat outstanding from the others, 14 June (grassland) and 16 June (water).

Evening trapping for both habitats again demonstrated the same seasonal trend as morning and noon collections (Figure 4.06, A and B). The nonrandom

Fig. 4.04, A-B. Chironomid flight trap catches for the morning collection period on grass and water in the three study sites, MHSSA, Sierra Valley, CA, June through August, 1976.

(△= Site 1; ○= Site 2; □= Site 3)

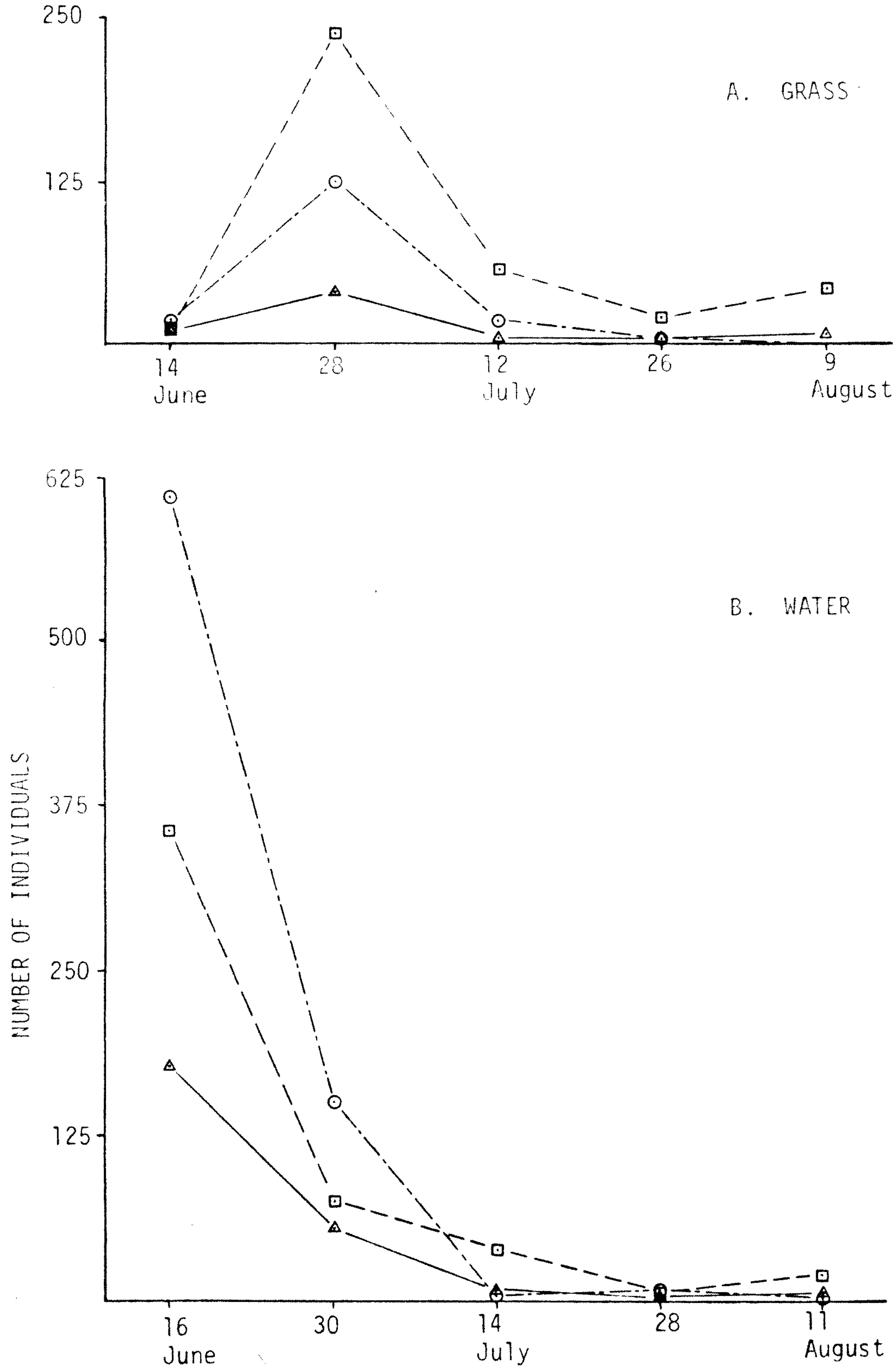


Fig. 4.05, A-B. Chironomid flight trap catches for the midday collection period on grass and water in the three study sites, MHSSA, Sierra Valley, CA, June through August, 1976.

(△ = Site 1; ○ = Site 2; □ = Site 3)

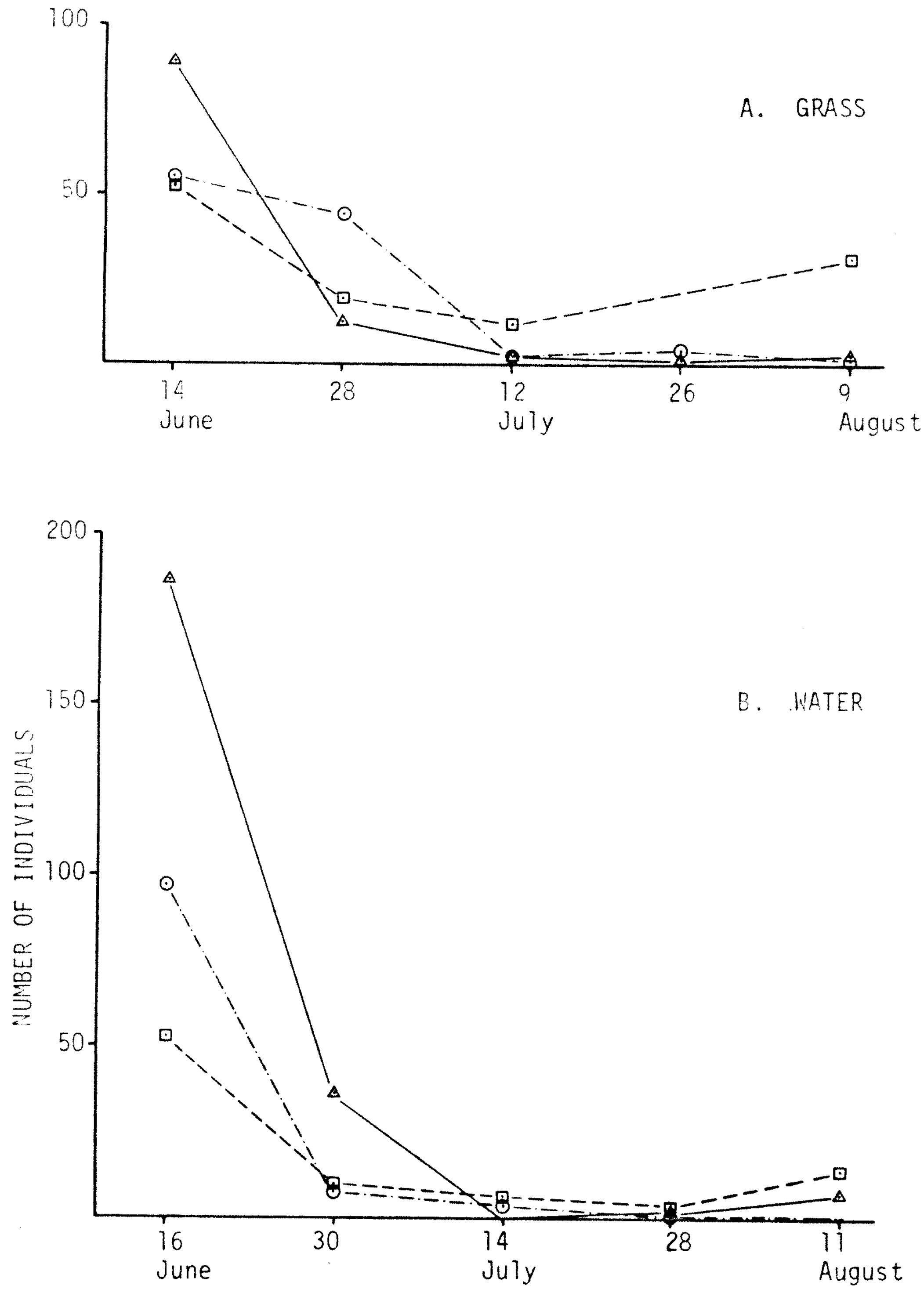
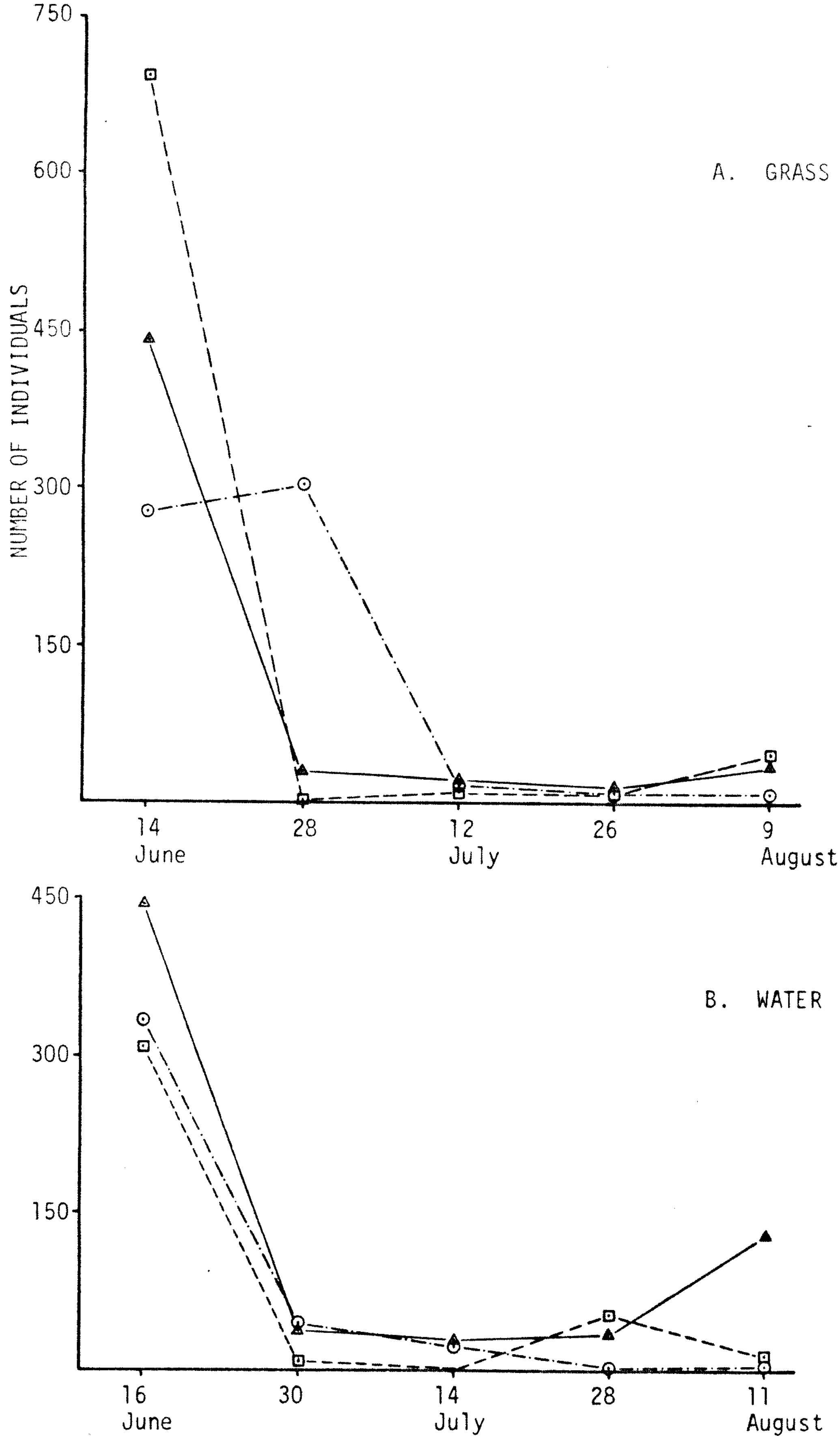


Fig. 4.06, A-B. Chironomid flight trap catches for the evening collection period on grass and water in the three study sites, MHSSA, Sierra Valley, CA, June through August, 1976.

(△= Site 1; ○= Site 2; □= Site 3)



summer activity (F = 6.64*) in grassland was caused by the high catches of 14 June. Collections on water showed a highly significant (F = 43.6**) change with MR isolating 16 June as the single significant difference.

The test did not distinguish any difference between the numbers of chironomids caught in each study site at any collection period.

Within each study site, the data appears to indicate morning or evening collection efforts to be the most productive, although RBD/AV failed to demonstrate this.

The chironomid catch is documented as showing similar seasonal patterns throughout the MHSSA. The almost unvaried high catches of 14 and 16 June correspond to the noteworthy swarms of midges attracted to an ultraviolet light set along the Area 2 roadside on the evening of 16 June. Here, the light trapping was abandoned when systematic collecting became impossible, due to the numbers of insects. The 4 by 7 ft white sheet placed in front of the light was at one point estimated to be under siege by 40,000 chironomids. The flight trap in SS2 was left out overnight and also caught a large number of chironomids indicating that this emergence was widespread throughout the study area. No similar occurrences were noted during the remaining field days of the study, although they may have occurred.

Overall, flight trap sampling yielded nearly 11,000 specimens. Of these, more than 6,200 (about 57%) were chironomids. It may be of interest to note that in SS1 and SS2, about half the total flight trap collection consisted of midges, while in SS3 they comprised nearly three-fourths of the flight trap specimens.

Dolichopodidae

The genus Dolichopus (Diptera: Dolichopodidae) was represented by three species. D. amnicola Melander and Brues, D. idahoensis Aldrich, and D. nigricauda Van Duzee. These accounted for nearly 5% of the insect specimens collected in flight traps during the study period.

Table 4.02 compares the total number of individuals of each species collected from flight traps in each study site. Of the 503 specimens of Dolichopus collected, D. idahoensis overwhelmingly dominated the genus with 450 individuals (89% of genus). Flight traps on water caught more specimens of D. idahoensis than those on grassland. Overall, this was represented by a 2:1 ratio, though the greatest difference was observed in SS2 where specimens from the water flight trap outnumbered those on grassland by more than 3:1. D. amnicola represented less than 8% of the genus (38 specimens). Flight traps set in either habitat of SS1 were the most successful in sampling this species. D. nigricauda was represented by only 15 specimens, and comprised only 3% of the genus. Most of these were collected in SS1 and SS2. All three species were poorly represented in SS3.

Table 4.02. Flight trap collections of three species of Dolichopus for both habitats of each study site. MHSSA, Summer, 1976.

Habitat	D. idahoensis			D. amnicola			D. nigricauda		
	SS1	SS2	SS3	SS1	SS2	SS3	SS1	SS2	SS3
Grassland	71	60	14	12	3	0	6	0	0
Water	99	188	18	18	4	1	2	6	1

The total catch per trapping day of the three species of Dolichopus is shown for each habitat in Figure 4.07, A and B. D. idahoensis was present throughout the summer but showed a rapid increase in numbers beginning in mid-July. It appears the population would have peaked sometime after the study ended. Although not frequently caught in the flight traps, D. amnicola did show a minor peak in occurrence in both habitats during mid-July. D. nigricauda was seldom encountered; the few specimens collected by flight traps were taken from the beginning of the study until mid-July.

It appears that the midday collection period was the least productive for sampling D. idahoensis with the flight traps (Table 4.03). In grassland, the noon collection period yielded only about 7% of the specimens, while mornning and evening periods produced 33% and 70%, respectively. Similar results were seen in flight traps placed on water, as the noon period produced only about 6% of the specimens, although morning and evening collections yielded 57% and 36% of the total catch. This activity trend was expected, as afternoon weather was frequently characterized by high temperatures and light or moderate winds (Chapter 2).

Table 4.03. Collections of Dolichopus idahoensis in flight traps, by date, time of day, and habitat. MHSSA, Sierra Valley, 1976.

Grassland				Water			
Date	Morning	Noon	Evening	Date	Morning	Noon	Evening
14 June	0	0	0	16 June	0	1	1
28 June	2	0	7	30 June	1	0	0
12 July	0	1	10	14 July	9	6	26
26 July	30	1	19	28 July	97	0	21
9 August	16	8	51	11 August	68	12	63

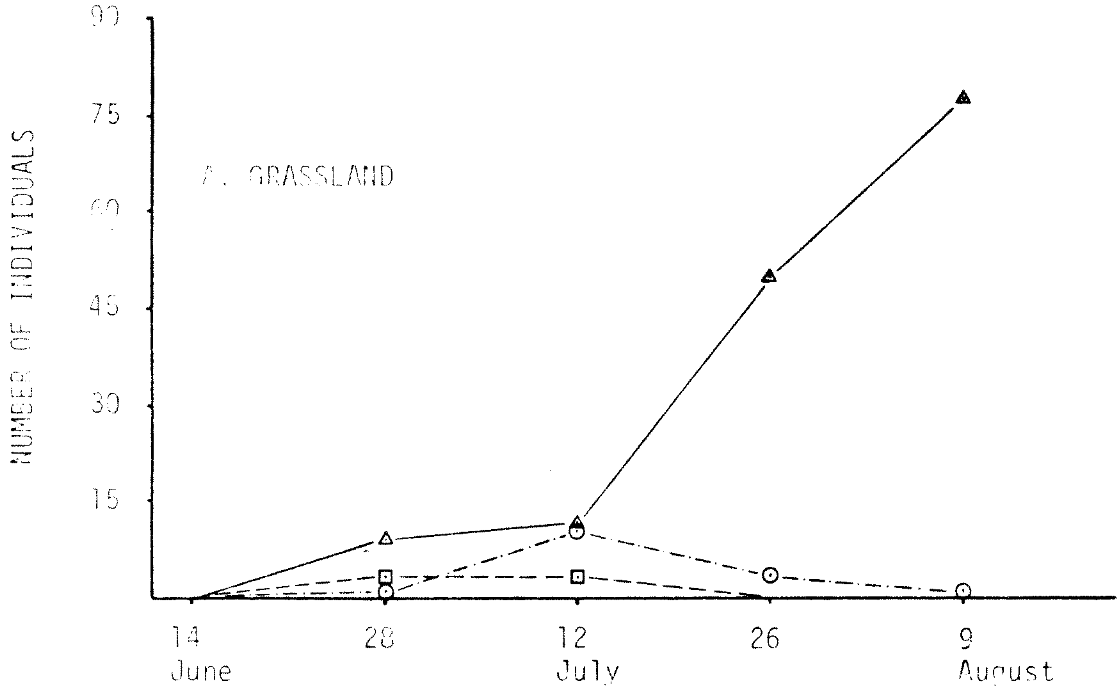
Discussion

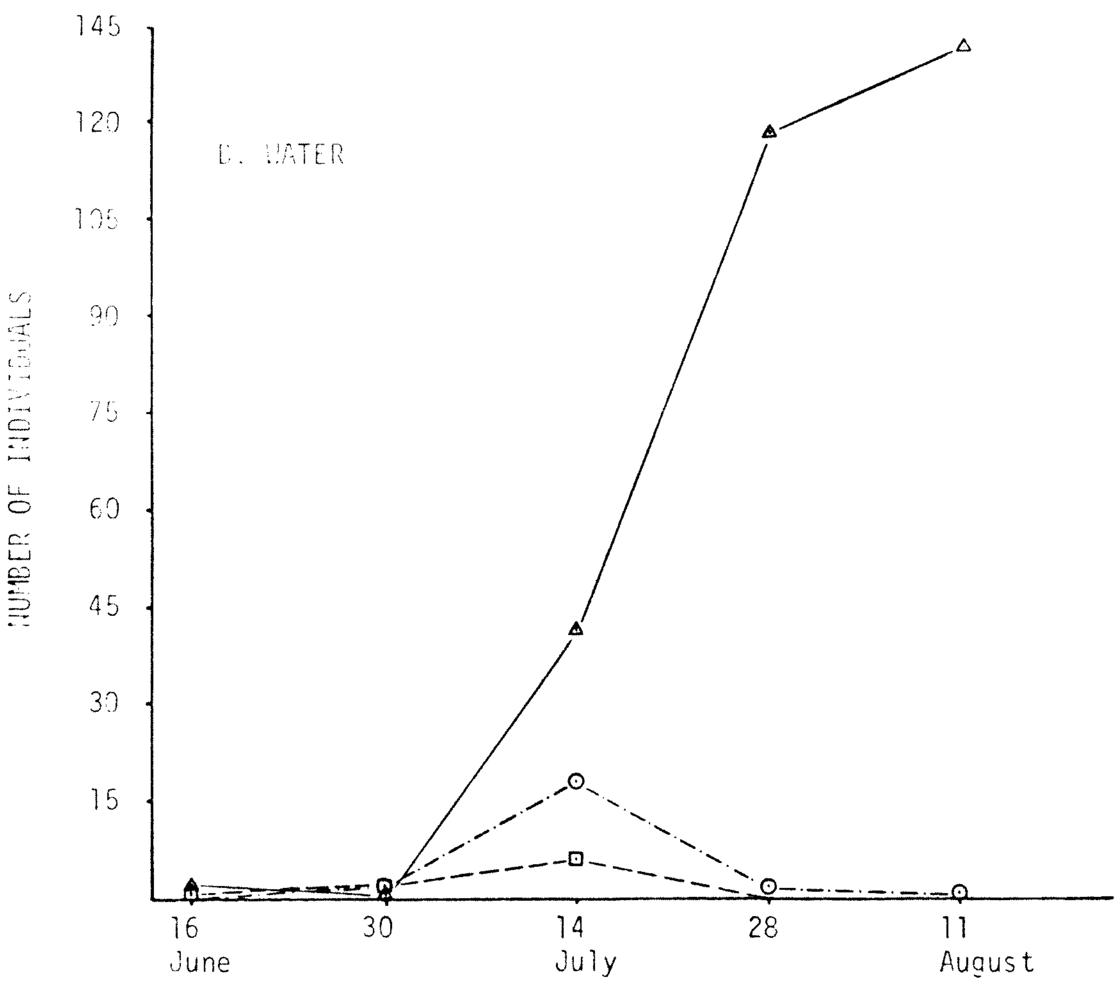
Problems with the flight traps did occur. Upon occasion, cows would congregate in and about the trap in SS2, and would frequently graze in close proximity to the SS1 trap. The presence of the cows and the subsequent dung produced a periodic and uncontrolled "baiting effect" which allowed traps to sample insects which would otherwise not have been seen. For instance, the sporadic occurrence of the horn fly, Haematobia irritans (Linn.)(Diptera: Muscidae), was undoubtedly concurrent with the presence of cows around the traps.

The relative efficiency of the flight traps for sampling insects varied with different groups. Ephemeropterans were very poorly represented in flight trap collections. Swarms of subimagos were often noted in the field and occasionally were seen to alight on the traps. Within minutes, the adults would emerge and fly away. The exuviae were not reliable estimates of the numbers which had landed on the traps, as they usually fell off the trap before the collection time.

The flight traps were of great value both as a systematic and general collecting tool. During regular systematic collection periods, collecting in

Fig. 4.07, A-B. Total catch of three species of Dolichopus in flight traps in two habitats of MHSSA, Sierra Valley, CA, June through August, 1976. (△ = D. idahoensis; ○ = D. amnicola; □ = D. nigricauda)





other areas could be pursued. In addition, traps were often run between the two-hour trapping periods for general collection purposes.

Three suggestions can be made for the future use of flight traps: 1) Trap numbers could be increased within an area to determine microhabitat preferences. 2) Trapping schedules could be increased to yield adequate numbers of groups for analysis. 3) By placing a number of traps in one given habitat, the relative efficiency of any one trap to sample highly mobile populations could be determined.

Pitfall Traps

Due to the large numbers of arthropods caught (sometimes hundreds per pitfall), priorities (based on abundance, ease of identification and/or uniqueness) were given to certain groups. While these priorities tended to favor predators, it should be mentioned that ants and leafhoppers were caught in numbers too great to afford sufficient time for their analysis. The unusual catches of immature aquatic insects and meadow voles are discussed elsewhere (Aquatics and Chapter 8). To date, all non-insect arthropods (grouped at least to order), a majority of the beetles (grouped at least to family), pompilid wasps, short-horned grasshoppers, jumping bristletails, and the larvae of the Ranchman's Tiger Moth (*Platyprepia virginalis*) have been tallied. Taxa which have not been reviewed are listed in Table 4.04. Figure 4.08, A-F shows the total numbers of each group of arthropods per site per week. Such numbers are shown biweekly in Figure 4.09, A-E so that general trends are more apparent.

Table 4.04. Arthropod groups not yet tallied* for pitfall catch analysis are listed. MHSSA, Sierra Valley, Summer, 1976.

Saldidae Lygaeidae	Dolichopodidae Sarcophagidae
Anthicidae Chrysomelidae Alticinae	Anthomyiidae small Diptera
small Coleoptera including Scarabaeidae	Chalcidoidea other small Hymenoptera

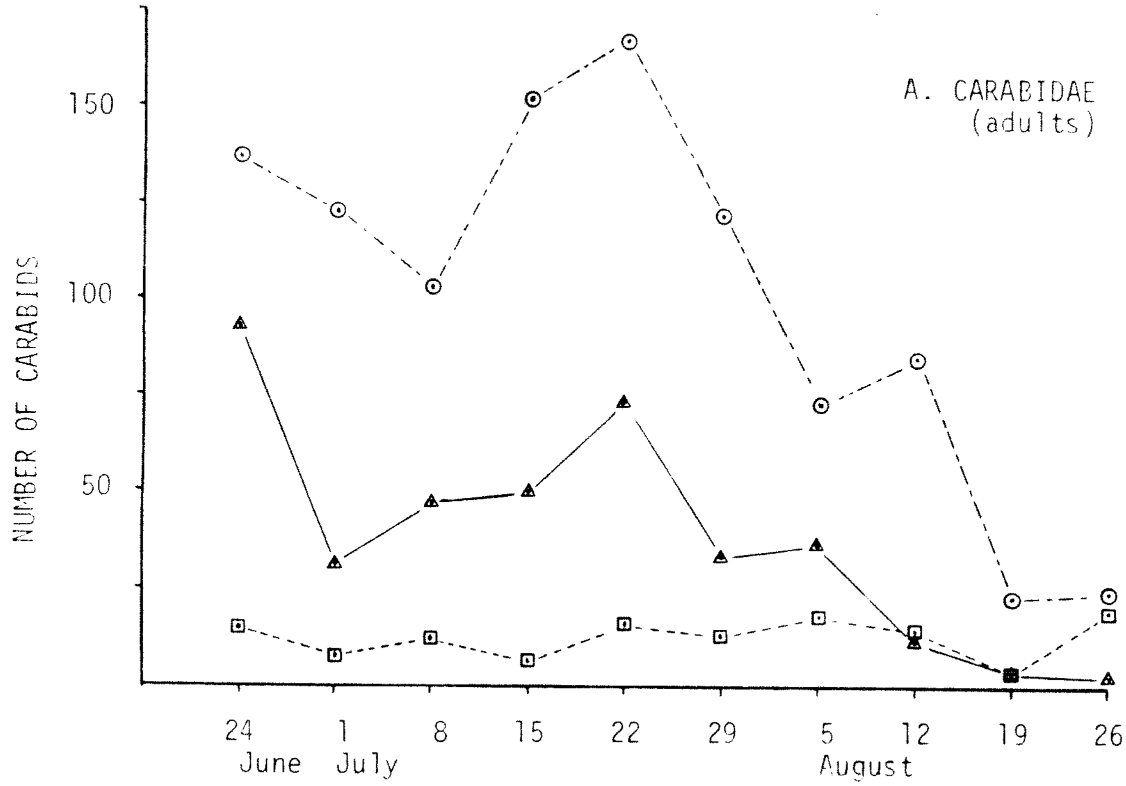
* Many other kinds of insects were taken in the pitfall catches, however their numbers were not great enough to warrant statistical analysis. They have been included in the species list (Appendix II).

When appropriate, random block design/analysis of variance (RBD/AV) and Keul's multiple range test (MR) were used to evaluate the following: 1) each group's distribution within the study sites; 2) differences in abundances between each study site; 3) numerical fluctuation during the summer.

Annotated Species List

Beetles of the family Carabidae comprised the largest group of coleopterans in pitfall traps, although they were not the most numerous collected in SS3. From a small sample of those collected, it is known that there are at least 29 species represented and that each may not necessarily be found in all

Fig. 4.08, A-F. Total pitfall catch per week for selected arthropod groups, in each study site, MHSSA, Sierra Valley, CA, 24 June - 26 August, 1976. (△ = Site 1; ○ = Site 2; □ = Site 3)



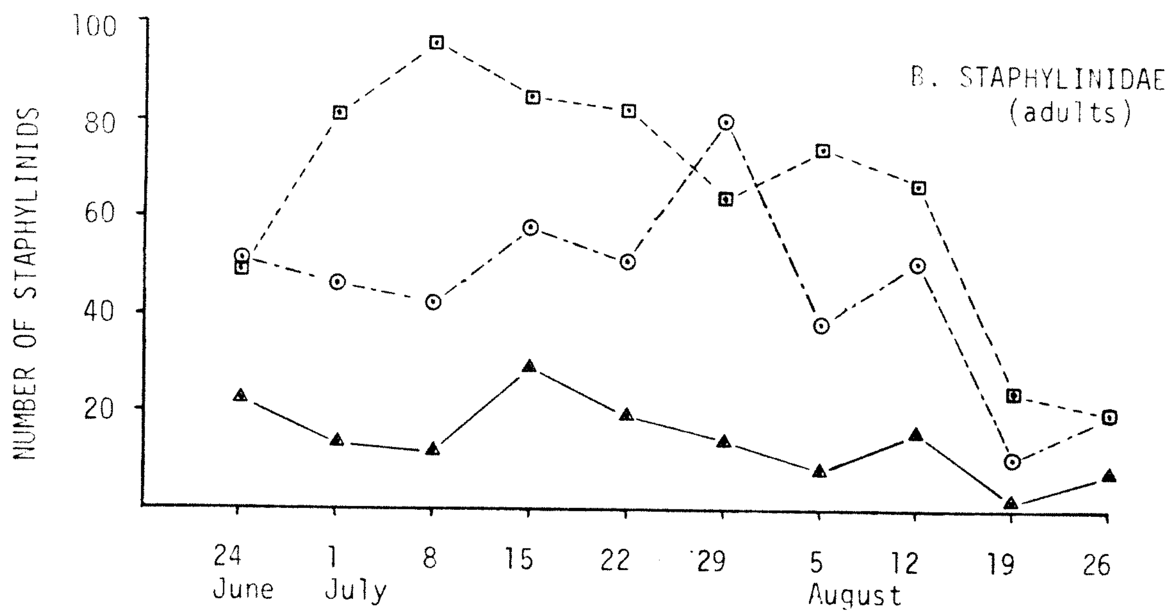
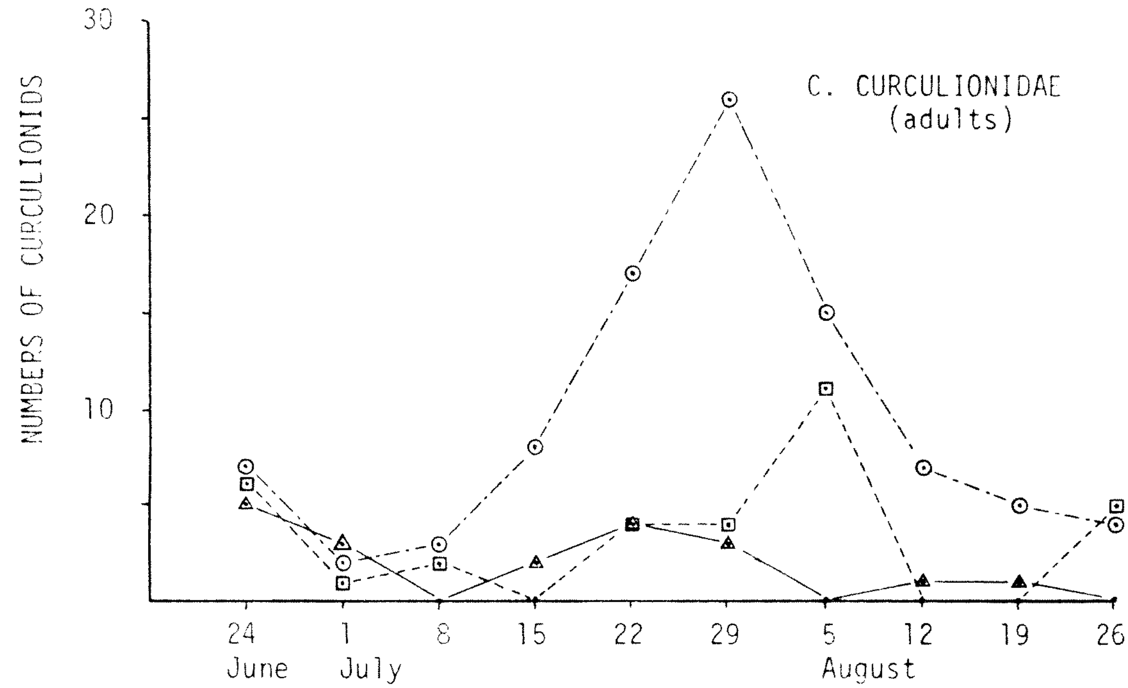


Fig. 4.08 (cont'd)



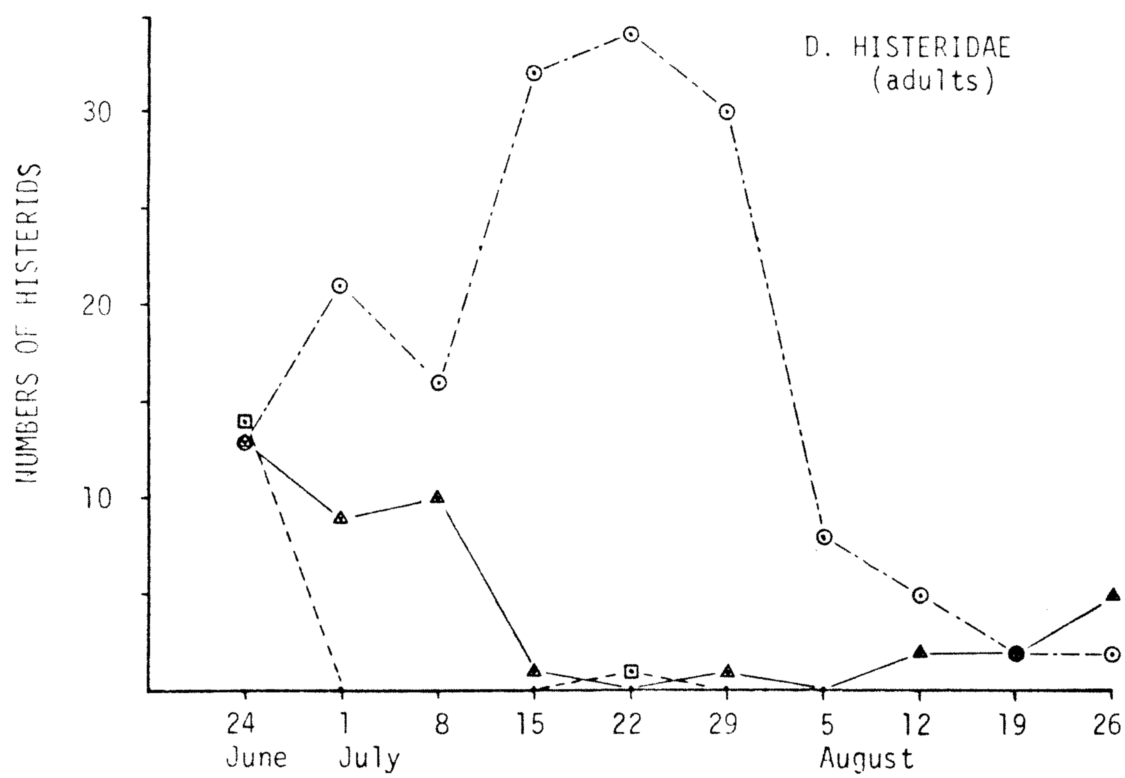


Fig. 4.08 (cont'd)

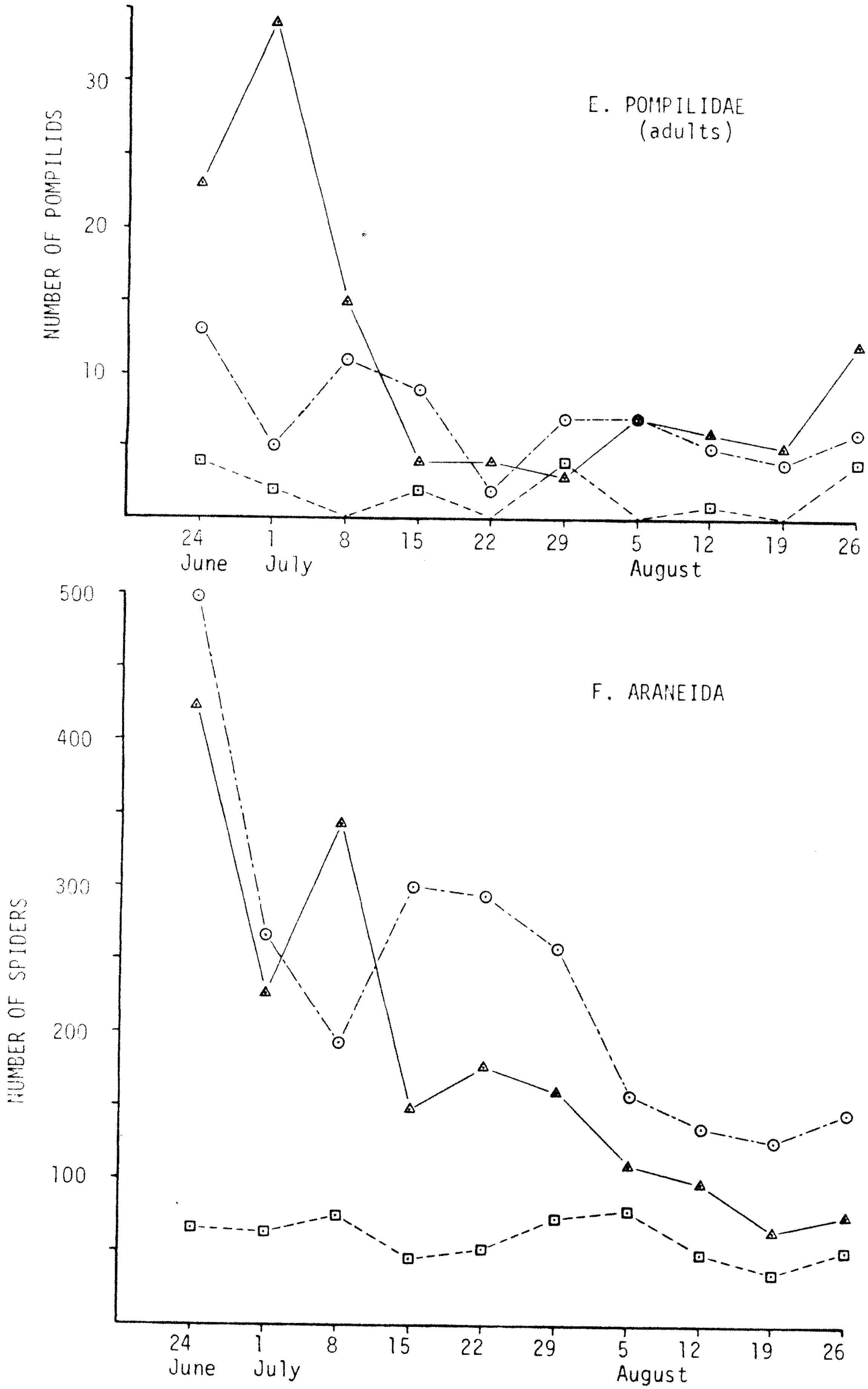
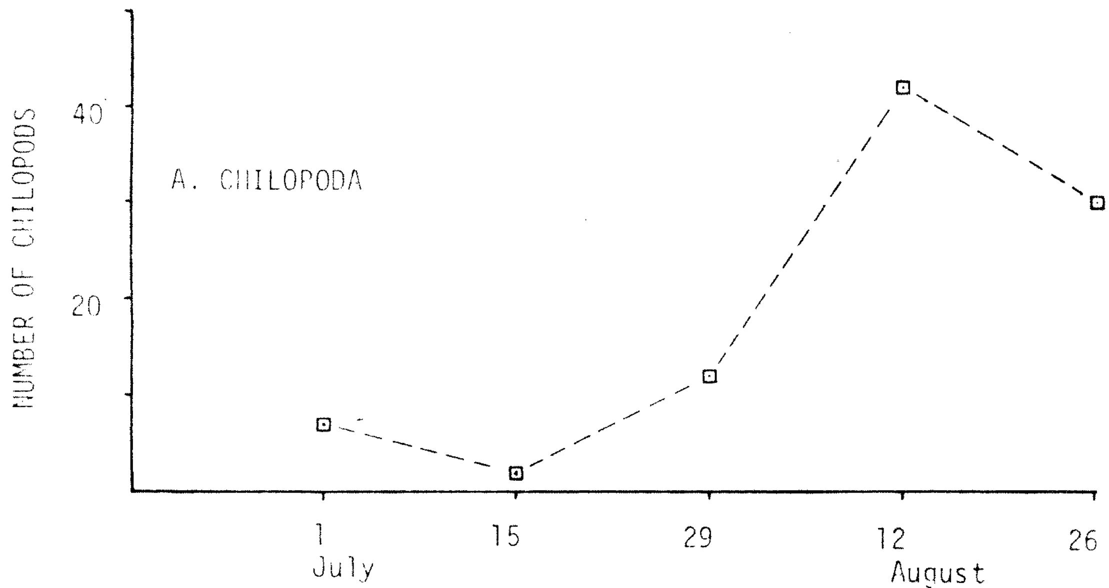


Fig. 4.09, A-E. Biweekly pitfall catches for selected arthropod groups, in each study site, MHSSA, Sierra Valley, CA, from 1 July to 26 August, 1976. (△ = Site 1; ○ = Site 2; □ = Site 3)



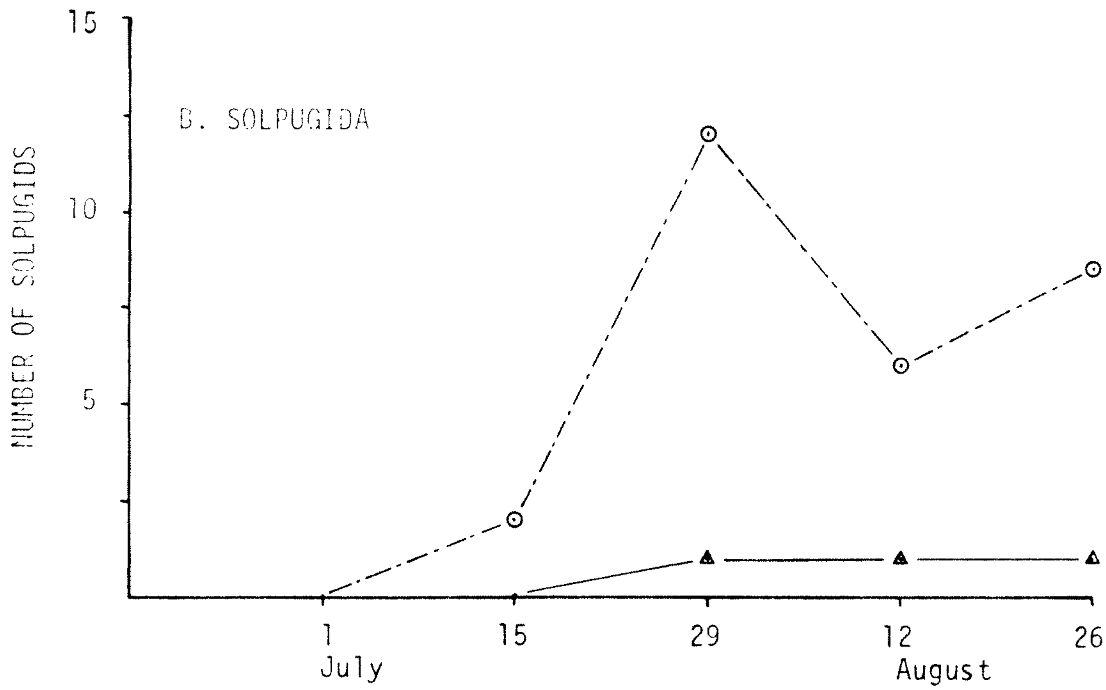
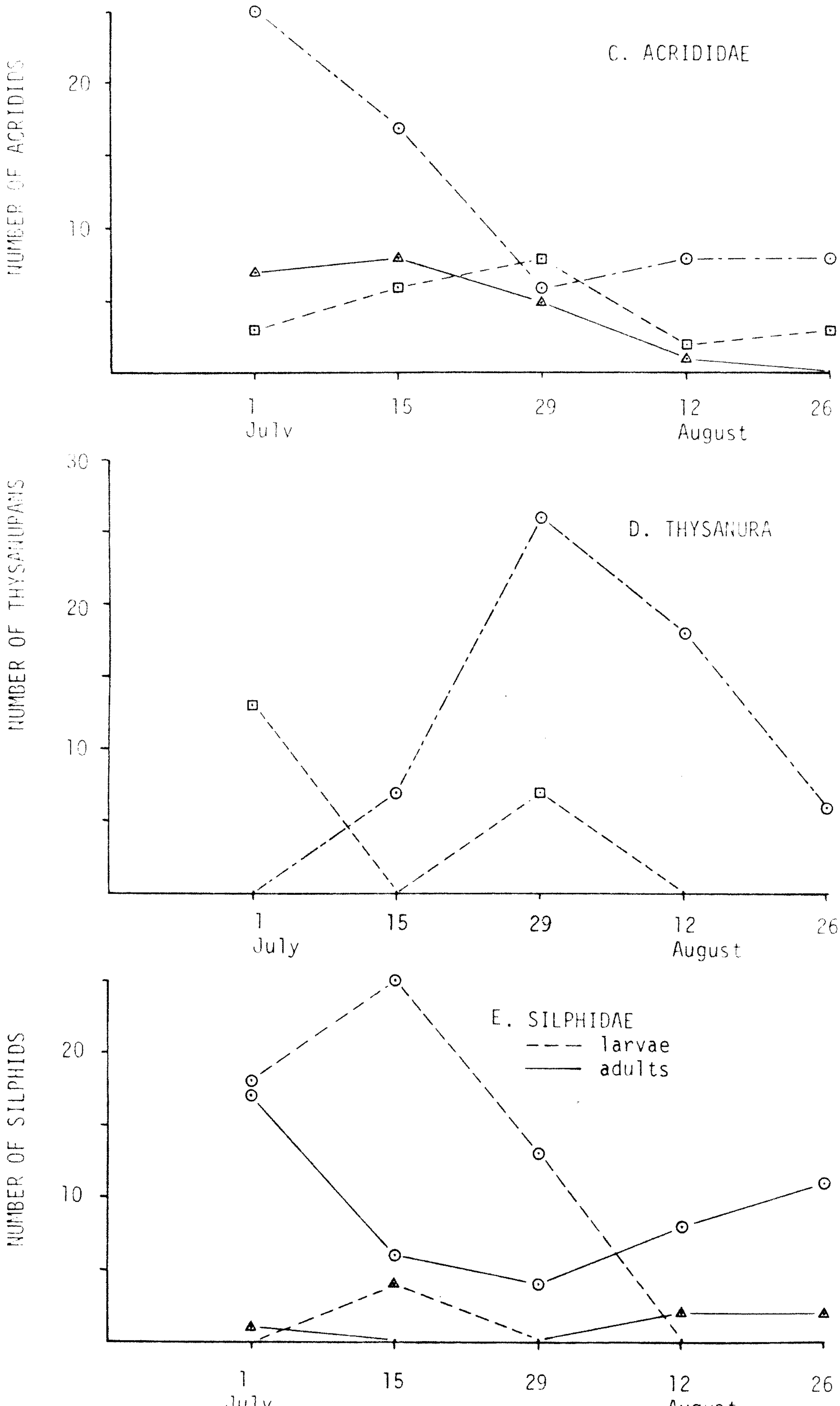


Fig. 4.09 (cont'd)



areas (Appendix II). A highly significant difference was found between the overall numbers of carabids in each area ($F = 28.82^{**}$). Catches within SS1 and SS2 showed highly significant nonrandom distribution patterns ($F = 6.12^{**}$ and 5.14^{**}, respectively). It is likely that different species have different degrees of specificity for microhabitat preference. This might be shown when statistical analysis is refined to the species level.

Although no significant change occurred in the number of carabids caught in SS3 during the summer, highly significant variations in the catch over time were found in SS1 and SS2 ($F = 4.36^{**}$ and 5.49^{**}, respectively). Catches in these areas suggest gross peak activities occurred at or prior to the initiation of the study and again in mid-July. These predatory beetles may be partioning the available resources spatially, temporally and/or using different prey species. Further resolution of the data at the specific level should shed light on this situation.

Members of the family Staphylinidae made up the second largest beetle group caught in pitfall traps and the largest in SS3 (Figure 4.08, B). Initial taxonomic work has indicated the presence of at least 17 species in this collection, including two genera, _Aleochara_ and _Platystethus_, associated with livestock dung. Population numbers differed significantly between each study site ($F = 28.43^{**}$). RBD/AV resolved nonrandom distribution patterns in SS2 ($F = 8.33^{**}$) and SS3 ($F = 9.19^{**}$). Although catch numbers changed significantly during the summer ($F = 2.2^{*}$), no catches of adjacent time periods varied significantly.

Weevils (Coleoptera: Curculionidae), although not highly abundant in pitfall catches, were one of the few phytophagous groups caught (Figure 4.08, C). The numbers taken in each area were significantly different ($F = 8.06^{**}$). Significant nonrandom distributions were found in SS2 ($F = 5.09^{**}$) and SS3 ($F = 3.30^{**}$). Although the data suggests that weevil activity peaked around the end of July, the statistical analysis did not bear this out, possibly because the sample size was too small.

Beetles of the family Histeridae, which are predators associated with dung, were slightly more numerous than curculionids (Figure 4.08, D). Their numbers differed significantly in each study site ($F = 9.43^{**}$). The numbers taken in SS3 were too low for statistical analysis of distribution patterns and summer fluctuations. SS1 and SS2 were found to have significant nonrandom populations ($F = 2.24^{*}$ and 6.54^{**}, respectively). Data for SS2 suggests that a peak activity period, in the area trapped, occurred between the middle and end of July. This is supported by an RBD/AV ($F = 3.68^{**}$). MR found that the significant decrease in numbers occurred after 29 July.

The numbers of spider wasps (Hymenoptera: Pompilidae) caught are shown in Figure 4.08, E. Although not caught in great numbers, they are of interest in that they are spider parasites. RBD/AV revealed a highly significant difference ($F = 6.90^{**}$) between the numbers of pompilids in each area: MR found a significant difference between SS1 and SS3. Highly significant nonrandom distributions were found within SS1 and SS2 ($F = 4.74^{**}$ and 4.43^{**}, respectively). These distribution patterns do not correspond to gross spider distribution. If the search area of the wasps is not much beyond the activity area of their prey species, it may be possible to determine which spiders are parasitized by which wasps when the analysis of spider data is more refined. Pompilid activity,

although showing a significant change over time only in SS1 ($F = 2.81^*$), appears to have peaked at the end of June. As with the spiders, the possibility of a post-August activity peak cannot be precluded.

Of the arthropod groups trapped, spiders (Araneida) were by far the most numerous even though spiderlings were not included in the tallies. Visual estimates, both in the field and of catches taken, suggest that lycosids were predominant. Salticids were seen often, but demonstrated an ability to avoid being trapped. Spiders which spend less time on the ground are not as well represented in the catches. Their appearance in the data may coincide with times that nearby vegetation was cropped by cattle. A further breakdown of spider catch data to the family or the generic level may support these observations.

Although a general trend indicated that there were more spiders in SS2 than in SS1 (Figure 4.08, F), this was not shown to be statistically significant. Both SS1 and SS2 had more than SS3 ($f = 16.24^{**}$). Why spider numbers changed little through the summer in SS3 as compared to SS1 and SS2 may emerge when the group is split to the family or generic level and a more definitive comparison is made. Spiders in SS3 showed a statistically random distribution over the area trapped, whereas SS1 and SS2 spiders had highly significant nonrandom distributions ($F = 17.68^{**}$ and 18.39^{**}, respectively). Major spider activity was recorded by those traps set closest to water. This may be reflecting the dominance of water-associated lycosids.

Apparently, peak spider activity in areas trapped occurred on or before the time of the first catch (June 17). With such a heterogeneous group, no correlation with seasonal temperature variations can be made. It is possible that some species limit their activity during the heat of the summer, and a resumption of activity may have occurred sometime after August 26. Other species may have moved out of the trap areas to stay in moist areas. Again, there is the possibility that they returned at the end of August or later as the water returned.

Centipedes, order Lithobiomorpha, were caught only in SS3 (Figure 4.09, A), from June 21 through August 26. Their numbers indicate a nonrandom distribution pattern ($F = 3.66^{**}$). Traps collecting the greatest numbers were located on the west side of the site and were further from water than other traps. Centipede catches also varied significantly over time ($F = 3.53^{**}$). The peak of centipede activity in the study site appears to have occurred early in August.

<u>Eremobates septentriones</u> Muma was the only species of Solpugida found (Figure 4.09, B). With the exception of one male caught in SS2 on 22 July, all solpugids were immature. Numbers of solpugids caught were too low to statistically indicate any distributional patterns or seasonal activity variation. The first solpugids appeared in the 12 July catch in SS2. For the duration of the study, 29 were caught in SS2, three were taken in SS1 and none in SS3. One immature was caught on Dyson Lane opposite SS2 at 8:45 a.m. on 22 July. Another was taken from the bathroom of Miss Money's residence west of MHSSA off Highway A23, at the beginning of August. Two more were collected from the sage west of SS1 on September 25 by the Ecological Physiology class of SFSU.

The number of grasshoppers (Orthoptera: Acrididae) caught in pitfall traps was low but followed an interesting pattern (Figure 4.09, C). A majority

of the nymphs had been taken by late July. A few nymphs were caught sporadically through the summer in SS2, and one was taken in SS3 on 23 August. With the exception of one adult caught on 24 June in SS2, adults began appearing in the catches in mid-July and continued to do so through the remainder of the summer. This suggests that one generation occurred during the 10 weeks of trapping. It may be possible that one generation preceeded, and one followed, the summer field work.

Figure 4.09, D shows numbers of specimens of the family Machilidae (Thysanura) caught in SS2 and SS3. Ground activity appeared to have peaked toward the end of July. The initial June activity in SS3 was not sustained through the summer. It is possible that more than one species was present.

Both larvae and adults of Silpha rammosa Say (Coleoptera: Silphidae) were caught in SS1 and SS2 pitfall traps. Figure 4.09, E shows activity for both life stages. Distribution patterns in SS2 for both immatures and adults were significantly nonrandom ($F = 2.49^{*}$ and 3.17^{**}, respectively). A significant change in numbers caught during the study was also found ($F = 4.43^{**}$ and 2.88^{*}). Although the numbers collected in SS1 were much lower, the larvae-adult activity mirrored that of SS2.

Woolly bear larvae (Lepidoptera: Arctiidae) were seen in great numbers in the marsh vegetation of SS2 in early June. By mid-June a migration out of the wet areas had begun. It is assumed that they were seeking drier, sheltered places in which to pupate, as several were found spinning cocoons under old cow dung. One such pupating larva was found in SS3 and taken to the laboratory at the Sierra Nevada Science Field Station. It emerged several weeks later and was identified as Platyprepia virginalis Boisduval.

The larval migration was recorded in the pitfall traps of SS2 (Figure 4.10). It had begun by the time the first pitfall catch was collected, and apparently peaked by June 21. No larvae were caught after July 5. No new larvae were seen for the remainder of the field work.

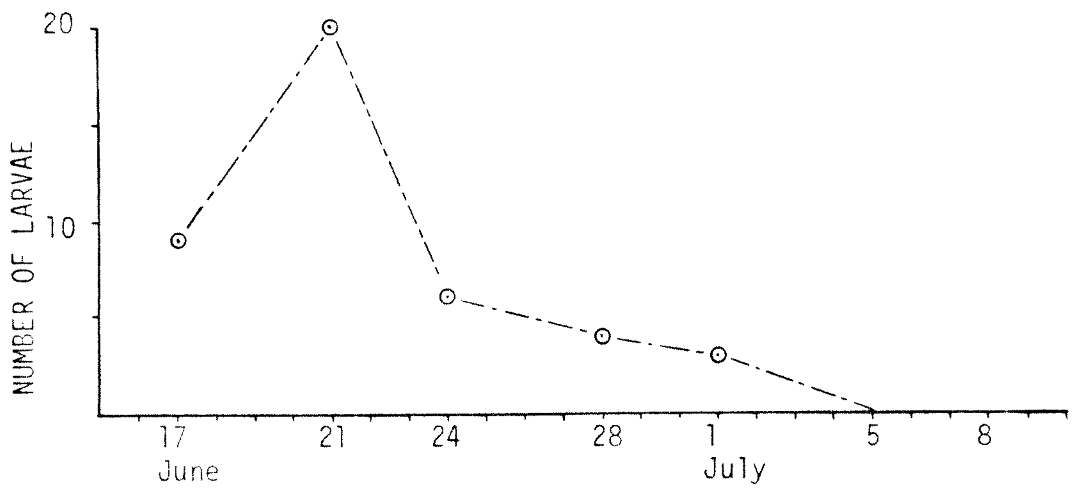
Discussion

Thus far, 8566 arthropods have been tallied; 30% were from SS1, 52% were from SS2 and 18% from SS3. Weekly catch size ranged from 582 to 78 in SS1, from 768 to 186 in SS2, and from 211 to 78 in SS3. SS2, with its mosaic of flooded areas and vegetation types appears to have had a more productive and varying environment for ground-dwelling arthropods than the other sites where water was confined to channels. The depression of abundance and diversity, along with the abundance of dung-associated staphylinid beetles, in SS3, may be the result of overgrazing by cattle in that area.

Pitfall trapping has proven to be a good method for surveying ground-dwelling arthropods over a period of time. This technique, however, did have some shortcomings. The original program called for 20 traps to be set in each study site. This had been done. However, clearing all animals and debris from 20 traps, with only forceps, took one person between four and five hours. For this reason, the number of traps was reduced to 10 per study site and aquarium nets were used. With a little practice, clearing ten traps could be done by one person in about one hour. It had been feared that minute animals in the traps would escape detection, however insects as small as 3/4 mm showed up regularly in the catches.

Cows, which grazed all three areas, also introduced problems. Most

Fig. 4.10. Total pitfall catch of larvae of the Ranchman's Tiger Moth (*Platyprepia virginalis*), taken only in Study Site 2, MHSSA, Sierra Valley, CA, 17 June to 1 July 1976.



probably due to curiosity, they frequently flipped the masonite lids off the traps. Dirt was often knocked into the traps and had to be removed and sifted for arthropods. One trap, No. 16 in SS2, was damaged prior to the 5 August collection and was replaced, on 9 August. For this reason catch data from this trap is slightly biased.

Pitfall trapping is a simple, though fairly time-consuming, consistent technique for monitoring changes in arthropod numbers over time, as well as for general collecting. This method can be duplicated in subsequent years, and data can be used to compare year-to-year variations and to record the effect of gross environmental changes on ground-dwelling and ground-frequenting arthropods. Two points, however, must be kept in mind: 1) Trapping areas used were selected because they appeared reasonably homogeneous. Our experience has shown that for much of the fauna collected this was not the case. Not only did the numbers of some arthropod groups vary significantly from site to site, but many showed clumped distribution patterns within sites. 2) Many of the groups caught were not taken in sufficient numbers for statistical analysis. These may be groups which will prove to be useful tools in monitoring changes in the environment. It may prove worthwhile to use more traps in order to get reliable estimates of their relative numbers, distribution patterns and numerical fluctuations over a given time period.

SUMMARY

Thus far, at least 452 species, of at least 154 families, of arthropods have been identified from collected material.

Aquatic sampling, using light traps and dip nets, yielded about 6500 specimens, representing at least 86 species of 35 families. Specimens of _Daphnia_ (Crustacea: Cladocera), although taken in only a few catches, comprised 37% of the total collection. Eight percent of the total were mayflies, with _Callibaetis_ sp. dominant (99%). Beetles (Coleoptera) had the greatest diversity, with seven families and 40 species represented.

Sampling with flight traps yielded about 11,000 specimens. Of these, 57% were midges (Diptera: Chironomidae). Of three species of _Dolichopus_ (Diptera: Dolichopodidae), _D. idahoensis_ comprised 89% of the total. Mosquitos were not abundant during the summer of 1976.

Of the almost 9000 arthropods tallied thus far from pitfall collections, spiders, carabids (Coleoptera: Carabidae) and staphylinids (Coleoptera: Staphylinidae) dominated. The relatively depressed abundance of arthropods in SS3 may have been directly related to overgrazing by cattle in that area.

CHAPTER 5
FISH

INTRODUCTION

The fish study was carried out by two people. The major emphasis of this study was to obtain an understanding of the population dynamics that existed in the Marble Hot Springs Study Area from June through August, 1976. Inclusive in this is an analysis of the relative abundance, length, weight and growth of various species as well as an examination of the reproduction and food habits of the dominant species, *Ictalurus nebulosus*.

METHODS

Because of the difference in response to various methods of collection by different species and size groups, the use of only one method would result in the disproportionate representation of sizes and species among the fish caught. For this reason we attempted to obtain representative samples by employing a variety of collection methods.

Commercial Minnow Traps

Twelve traps were purchased from the Twin Rivers Company, Eureka, California. Each trap was 12 inches in diameter and 30 inches in length. The traps were cylindrical in shape and funneled at both ends. The mesh defining the body of the traps was one inch by 1.5 inches. Each trap was equipped with a center receptacle for bait so that the actual bait mass was isolated from the trap occupants. These traps were used both with bait, as a luring device, and without, as an interception trap. Each trap was positioned so that the funnels were directed parallel to the water flow.

Small Minnow Traps

Fifteen minnow traps were obtained from the Biology Department Stockroom at San Francisco State University. Each trap was cylindrical in shape and measured 12 inches in circumference and length. The use and positioning of these traps was the same as that for the larger commercial minnow traps.

Seine

Several seines were used throughout the study period. The seine which proved the most functional under the prevailing conditions was a nine-foot minnow seine with a half-inch mesh. Depending upon the study area, the seine was hauled parallel to shore or pulled from deeper waters to the bank.

Dip Netting

A 12-inch by six-inch rectangular net worked from the end of a counter balance pole was used in small, isolated pools. In these areas, using this method, we collected a large number of small fish in a relatively short period of time, this being possible because of a high concentration of fish within these collection areas.

Hook and Line

Set lines with one to two hooks were employed in the more remote or deeper water areas that would otherwise not have been sampled. Locally purchased worms were used almost exclusively as bait.

Electrofishing

A Smith-Root Amplifier Type V and battery were used as a portable electrofishing unit. The unit was carried back pack style and weighed approximately 50

pounds. The electrodes consisted of an aluminum wand anode and two copper mesh cathodes, the latter of which were strapped to the shins of the operator. In operation, one of the two workers carried both electrodes and the other worker carried a dip net. The effect of this method is to stimulate a muscle contraction along the body of the fish and render them momentarily immobile. Fluctuations in pulse and frequency output were made possible by adjustment dials on the amplifier unit.

Marking of Fish

Marking is an important technique for studying fish populations, and there are available many different ways to mark fish so that they may be recognized on recapture. In an attempt to determine the most efficient method within our budget, a controlled experiment was run to ascertain: 1) comparative value of different types of methods; 2) rate of disappearance of marks: 3) mortality of fish due to handling and/or the marking means employed; 4) effect of mutilation on behavior patterns necessary for survival (swimming and feeding patterns). This controlled experiment tested the various merits of two types of marking by comparing plastic bead tags (attached by monofilament line) to fin clipping. While tagging has many advantages over fin clipping, we decided to utilize fin clipping based upon the results from our controlled experiment. After two weeks in the control tanks (which were artificially planted with vegetation to simulate the habitat conditions of the marsh), several of those fish marked with tags had experienced either a loss of their tags due to entanglement in the vegetation (and ripping of the membrane at the attachment site) or immobility (as they were trapped in the dense vegetation by the dragging tag).

Fin clipping is a common technique for marking fish, particularly fish with adipose fins. A review of the literature (Fry, 1961; Hale, 1954) showed that over a two to three month period, regeneration of clipped fins for a variety of fishes was not extensive enough to present a problem to the experienced observer of identification of marked fish versus unmarked fish. Our controlled experiments seemed to support this conclusion, as regeneration in the aquarium-maintained fish over a three-month period was not extensive.

Fin clipping does have some very definite drawbacks. It does not supply the individual identification of each specimen--a factor that is very important in any study of the population dynamics of a fisheries system. Moreover, our controlled experiment may not actually indicate the impact of this mutilation upon the fish in his natural habitat. The long-term mortality associated with escaping predators and competing for food "...usually cannot be detected simply keeping marked or unmarked individuals in captivity, for no matter how long a period" (Ricker, 1949). While our study may be called a short-term study, and thus avoid some of the problems inherently associated with fin clipping, it is our recommendation that a more sophisticated tagging method be used, if the monies are available, for any similar study in the future.

Holding Boxes

In an effort to further insure that there were no undue mortalities due to handling or mutilations, holding boxes were constructed for use in the field to house the fish between catch periods. This allowed for a controlled period of time after marking in which we could assess the health of the fish before redepositing them back into the population. The use of these boxes provided yet another important benefit. Ofter while one haul of fish was being recorded, those

individuals to be measured and recorded last were subject to severe stress due to the holding conditions (either an overcrowded bucket or worse, on a moist surface). Use of a holding box alleviates these stress conditions. These boxes were nothing more than a wooden frame covered on five surfaces with a fiberglass screen. This construction permitted them to float and also to have a constant circulation of fresh water.

Selection of Study Sites for Sampling

In collecting fish for this study, every effort was made to collect not only in areas where fish were obviously in evidence or highly concentrated, but also to collect in the more obscure places (Table 5.01 and Figure 5.01). The purpose was to obtain samples that were representative rather than selective. A report by the Department of Water Resources (CPA/1020.10), in addition to some preliminary sampling efforts, provided an indication of those fish types that could be expected in the MHSSA (Table 5.02). Along with this knowledge, and an understanding of previously documented habitat preferences for each type, we sought water systems which would satisfy any one of the following criteria: 1) stagnant to moderate water flow; 2) high to low density of aquatic vegetation; 3) mud or mud with sand or gravel substratum; 4) open or closed water system; 5) extreme to moderate water fluctuation. The assessment of many of these conditions was subjective as the location and number of sample sites was beyond the realm of an extensive physical parameter analysis.

Table 5.01. Characterization of sample sites selected for fish study, MHSSA, 1976.

Sample Site	Location	Waterflow	Substratum	Open or Closed Water System
SS1	Fig. 5.01	sluggish	mud	closed
SA2	Fig. 5.01	stagnant	mud	closed
SS3	Fig. 5.01	moderate	mud/sand	open
1W	Fig. 5.01	stagnant	mud	closed
1E	Fig. 5.01	stagnant	mud	closed
1.5E	Fig. 5.01	stagnant	mud	closed

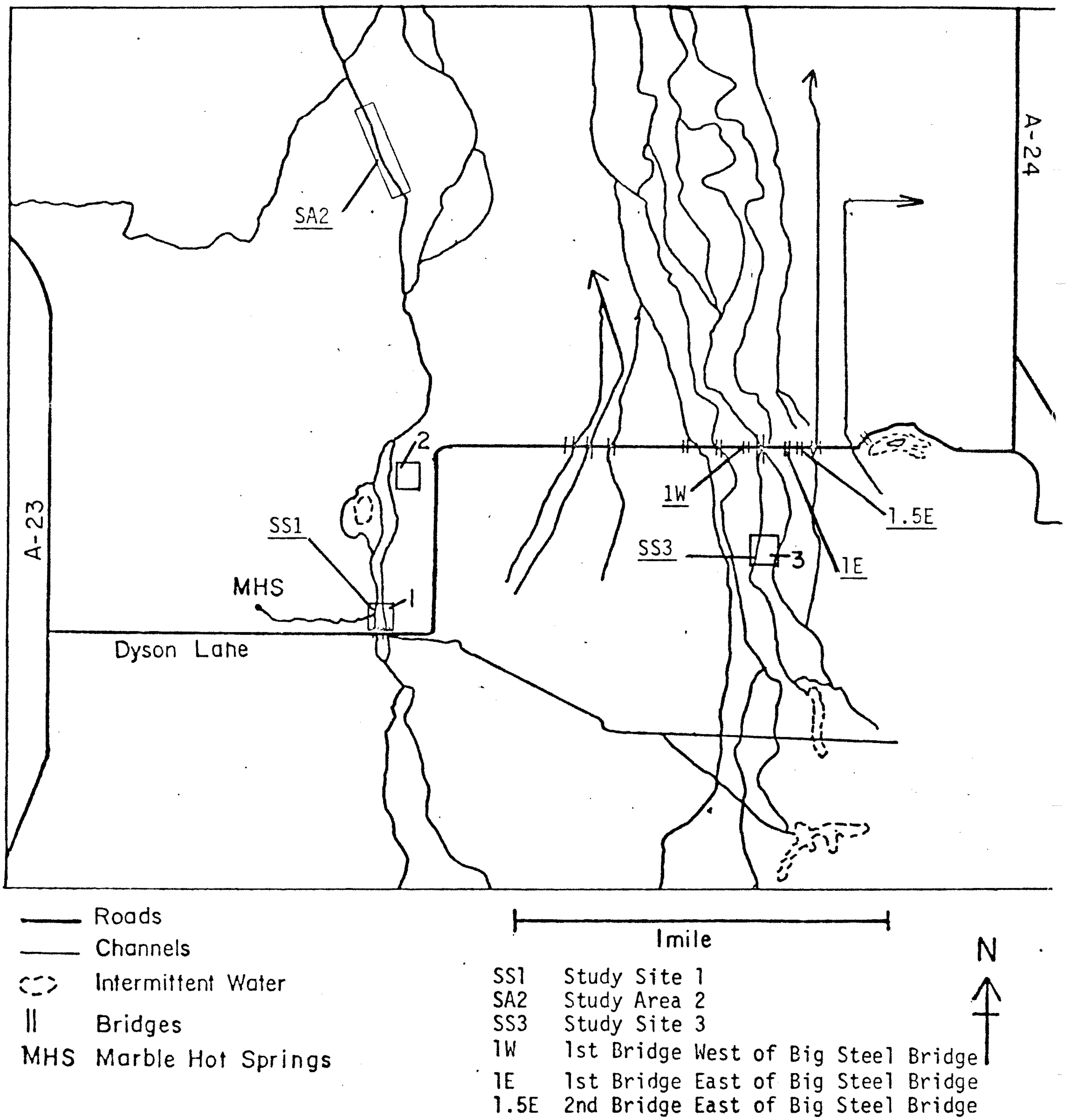
Table 5.02. List of fish species found in MHSSA, June through August, 1976.

Scientific Name	Common Name
Ictalurus nebulosus	Brown Bullhead
Cyprinus carpio	Carp
Notemingonus crysoleucus	Golden Shiner
Lepomis cyanellus	Green Sunfish
Catostomus occidentalis	Western Sucker
Micropterus salmoides	Large Mouth Bass
Salmo gairdneri	Rainbow Trout
Salmo trutta	Brown Trout

Physical Characteristics of *I. nebulosus*

Seventy-two of the captured bullheads were removed randomly and weighed. This process in addition to the length measurements made of each captured fish and observations of the gonads, enabled us to calculate a length-weight relationship, size class distribution and average size at sexual maturity.

Fig. 5.01. Map showing locations sampled for fish, MHSSA, Sierra Valley, CA, June through August, 1976.



Food Habits

Various methods may be used when attempting to determine the food habits of any particular fish. However, each method has its own limitations. For example, a numerical count may indicate what occurs in large number in the stomachs but not what constitutes the most important food item, i.e., that which is the primary objective of any such study. In an attempt to overcome the bias inherent in any one method, several of the established procedures (Lagler, 1956) were combined: numerical, frequency of occurrence and weight. From these we were able to obtain an understanding of what kinds of foods were eaten, the number of individuals of each kind of food item, and the frequency with which each category of food is consumed.

The food habits of only bullheads were considered here, as other specimens were either too few in number or there was difficulty in identifying the contents of the stomachs. In support of this decision we offer the fact that as the one fish in the MHSSA in the greatest abundance, an understanding of its food habits would be more revealing of the baseline conditions of the marsh than a similar study done (in the limited time available) on fish playing a lesser role in the fisheries system of the marsh.

Seventy-two bullheads were collected for this study, of which only 20 were utilized. These collections were made randomly from Study Sites 1 and 3. The fish were preserved within three hours of capture time. Only those contents contained between the esophageal opening and the pyloric region of the stomach were used in this analysis. The stomach material was first categorized as plant or animal matter; a more in-depth analysis of these categories followed.

Bait

The effectiveness of the traps used as interception devices was tested against their use, with bait, as luring devices. There proved to be no significant difference in either the type of fish or the number of fish captured. This experiment was carried out in SA2 and in 1W, 1E and 1.5E (Fig. 5.01). As a result, bait was not used in any of the subsequent traps set in SS3 or in SS1.

Duration and Time of Sampling

Any one trap was set for at least 12 hours prior to collection. The duration of sampling at any one site varied with the fluctuations in water level. More specific information is shown in Table 5.03.

Table 5.03. Duration of sampling method according to sample site, MHSSA, 1976.

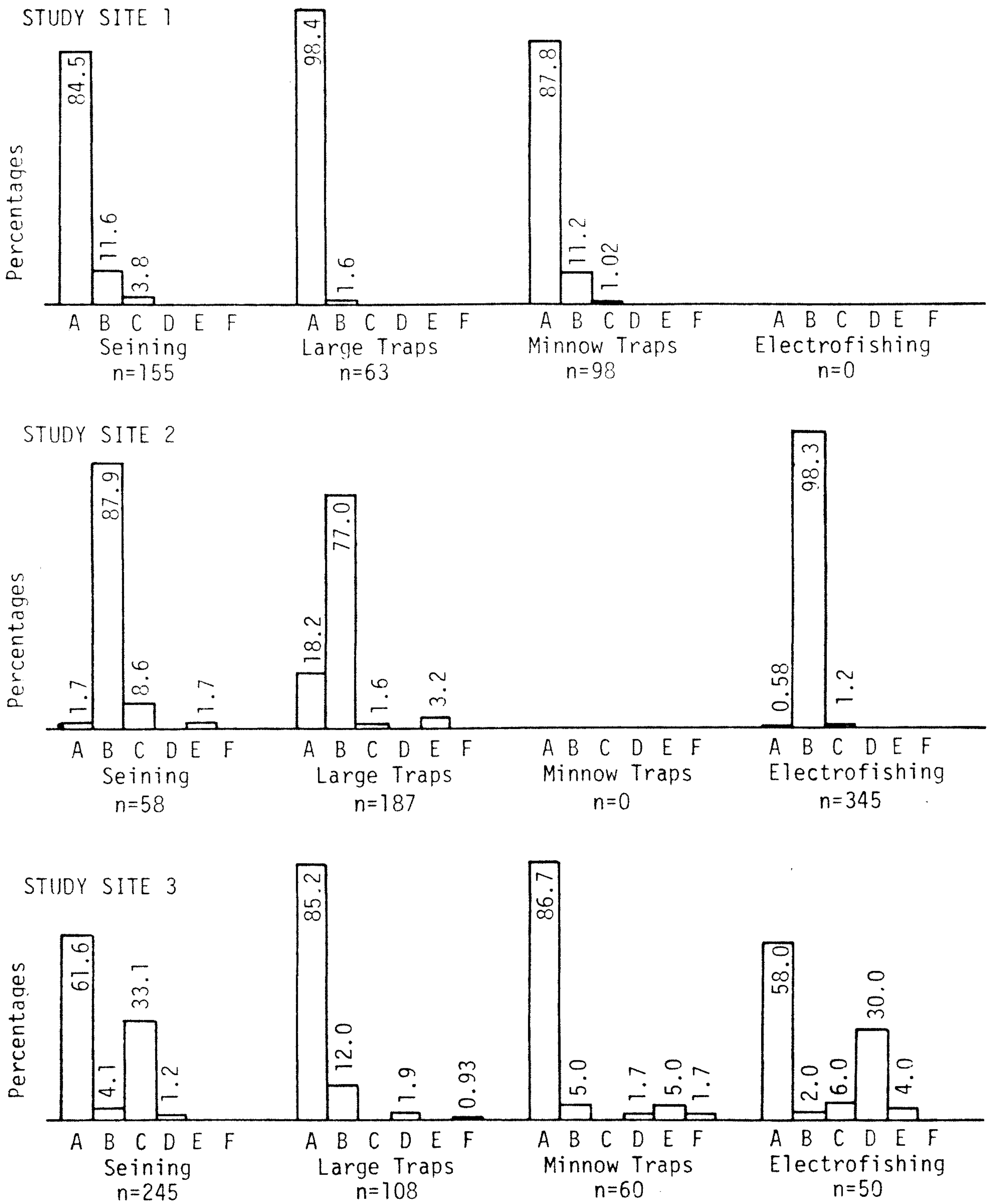
Method	Total Days	Total Sets	SS1 Days	SS1 Set or Sweep	SA2 Days	SA2 Set or Sweep	SS3 Days	SS3 Set or Sweep
Comm. M.T.	46	210	6	18	8	96	32	96
Small M.T.	38	295	6	70	-	-	32	225
Seine	20	88	6	22	2	2	12	64
Electro.	19	15	-	-	4	8	5	7

RESULTS AND DISCUSSION

Relative Abundance

The relative abundance of the six predominant species found in the MHSSA are presented in Figure 5.02. As different methods of collection select for

Fig. 5.02. Relative abundance of six fish species by collection method, MHSSA, Sierra Valley, CA, June, July and August, 1976. A. Ictalurus nebulosus, B. Cyprinus carpio, C. Notemingonus chrysoleucus, D. Micropterus salmoides, E. Lepomis cyanellus, and F. Catostomus occidentalis



specific size and types of fish, and because different species are predominant in different areas, the density data is subdivided according to location and according to method.

Study Sites 1 and 3 had the highest density of brown bullheads and a correspondingly low density of carp. Carp, in turn, were dominant in SA2. Although the location is not represented in Figure 5.02, the golden shiner and green sunfish were found in the highest abundance in 1W, 1E and 1.5E. Largemouth bass were found in only one area, SS3. While rainbow and brown trout were observed during the study period in SS3, their abundance was insignificant enough to preclude their inclusion in relative abundance figures.

The varying abundance of certain species of fish in the study sites and areas is significant enough to warrant an examination of several physical and biotic parameters that might dictate such a distribution.

Aquatic Vegetation

The aquatic vegetation cover was 78% in SS1 and 65% in SS3 (Chapter 3). A statistical analysis of the aquatic vegetation in SA2 was not made, as it was outside the actual study site. The plant biomass in this area was, however, more pronounced than in either of the aforementioned sites, as we were, in this area alone, unable to haul a seine through the water, as it was immediately clogged with vegetation. The very presence of largemouth bass appears to be inversely related to the density of the aquatic vegetation as this species was found only in that site where the plant density was relatively low. A dense concentration often serves as a detriment to largemouth bass distribution in many ways. One primary reason is that in an area dense with aquatic vegetation, a high eutrophication level is always possible. Therefore, the minimal O_2 tolerance of 1.5 ppm (Whitmore et al, 1966) serves as a definite limitation to their successful distribution and very presence in such an area. In addition, a larger population of forage fish is more likely where densities of aquatic vegetation are lower (Bennett, 1962). In support of this, forage fish such as the golden shiner and green sunfish were found in higher abundance in SS3 than in either of the other two sampled areas listed in Figure 5.02.

The lowest abundance of carp was found in the one area (SS3) with the lowest density of aquatic vegetation. Carp were, furthermore, most abundant in the one area (SA2) where the aquatic vegetation was relatively dense. This distribution results, perhaps, from the food habits of the carp where filamentous green algae and higher plants make up the largest percentage of their food intake (Dill, 1944; Wales, 1943).

Substratum

Largemouth bass will not spawn successfully when only provided a mud type of substratum (Robins, 1961). Spawning success is possible when a sand or gravel substratum is present (Curtis, 1949; Simon, 1951; Krame & Smith, 1962). The fact that largemouth bass were found in SS3, the only area where sand was found, and not in any other study site seems to corroborate this spawning requirement and account for their limited distribution.

Waterflow--An Open or Closed System

As indicated in Table 5.01, the water flow in SA2 and SS1 was part of a closed system in that it drained through ground seepage alone during the study period. SS3 is the only system that could be considered open. It is here that we find the greatest abundance of largemouth bass.

Interspecific Abundance Correlations

The presence and abundance of one species type will often dictate the relative dominance of another. The factors dictating such a correlation are multifaceted. One type may serve as forage food for another, and in turn determine its successful distribution. The direct relationship between largemouth bass and golden shiner abundance may be an example of one such factor. One type of fish may be sufficiently damaging to the habitat conditions to preclude the successful distribution of another. The fact that carp often disturb the substratum in their search for food so that the amount of suspended precipitate is increased to the detriment of other less tolerent species may be a factor explaining the dominance of carp in SA2 to the virtual exclusion of other species.

There were only eight species of fish found in MHSSA (Table 5.02). Often their relative distribution was such that no more than three species were found in any one area. Artificial eutrophication is occurring in inland waters at an ever increasing rate (Haines, 1973). The usual effect on fish is a decline in the number of species (Gaufin & Tarzwell, 1952; Hasler, 1947) and this appears to be the case in the MHSSA.

Length, Weight and Growth

Length

The majority of the largemouth bass collected were under 28.0 mm standard length. The largest was only 44.5 mm. No adults were captured. Carp predominated in SA2 where the mean sizes were 85.9 mm, 63.5 mm and 36.1 mm using large traps, a seine and the electrofishing unit, respectively. The largest specimen caught was approximately 305 mm and was found in SA2, an area which had mean lengths that were consistently smaller than those carp found in the other two study sites.

The largest bullheads were found within SS1 and SS3 where the mean length was 109.2 mm (Figure 5.03). The largest bullhead captured was 254 mm. Of the 272, 114 and 338 bullheads captured in the three sites, only 21%, 6.3% and 22% were greater than 150 mm (Figure 5.03).

Growth

Minnow traps were set several times throughout the study period in 1W, 1E and 1.5E to ascertain rates of growth for the bullheads. The mean lengths, as shown in Figure 5.04, were 54 mm, 60 mm and 61 mm in early, mid and late July, respectively. This data does not include any fry captured as none were seen until late August in these pools. The assumption is, therefore, that the bullheads in these small ponds were, at the earliest, a second year-class, having hatched in 1975. A similar study was done in SS3 at a later date and utilizing three large traps in addition to the eight minnow traps. The mean sizes were 105 mm, 132 mm and 147 mm in late July, early August and late August (Figure 5.05). Only one newly-hatched bullhead was included in this data and it appeared in late July.

Length-Weight Relationship

Based upon a sample size of 76 bullheads collected in SS1 and SS3 from July 15th to September 15th, a length-weight curve was constructed and is shown in Figure 5.06. Based upon the raw data, the mean weights are 26.6 g, 46.5 g, 85.2 g, 110 g and 205.8 g for bullheads of standard length 100 mm, 125 mm, 150 mm, 180 mm and 200 mm, respectively.

Fig. 5.03. Length frequencies (standard length) of *Ictalurus nebulosus* from Study Area 2 and Study Sites 3 and 1 sampled June, July and August, 1976, respectively. MHSSA, Sierra Valley, CA.

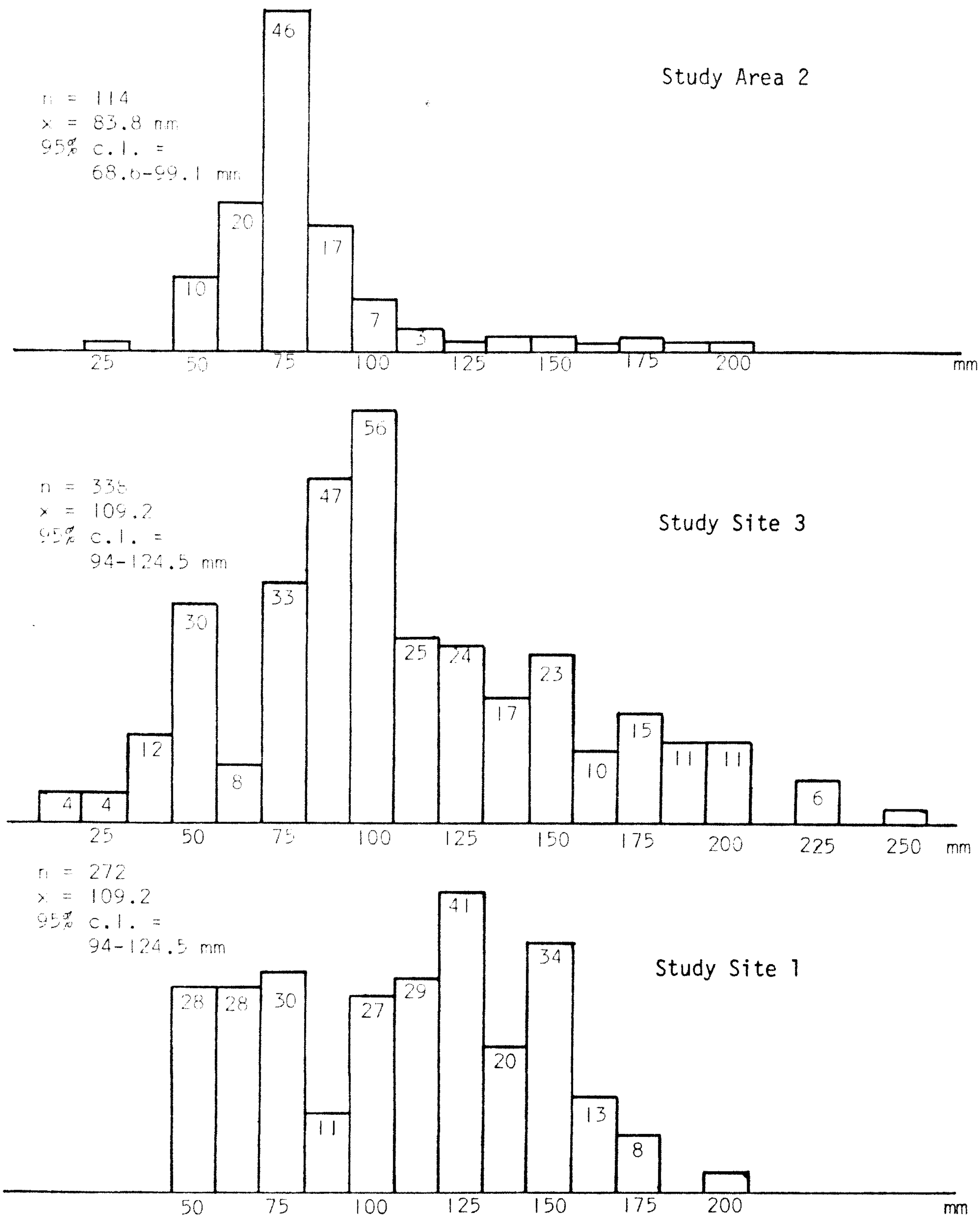


Fig. 5.04. Mean lengths reflecting growth over a four week period of brown bullheads collected from 1W, 1E and 1.5E, MHSSA, Sierra Valley, CA, 1976.

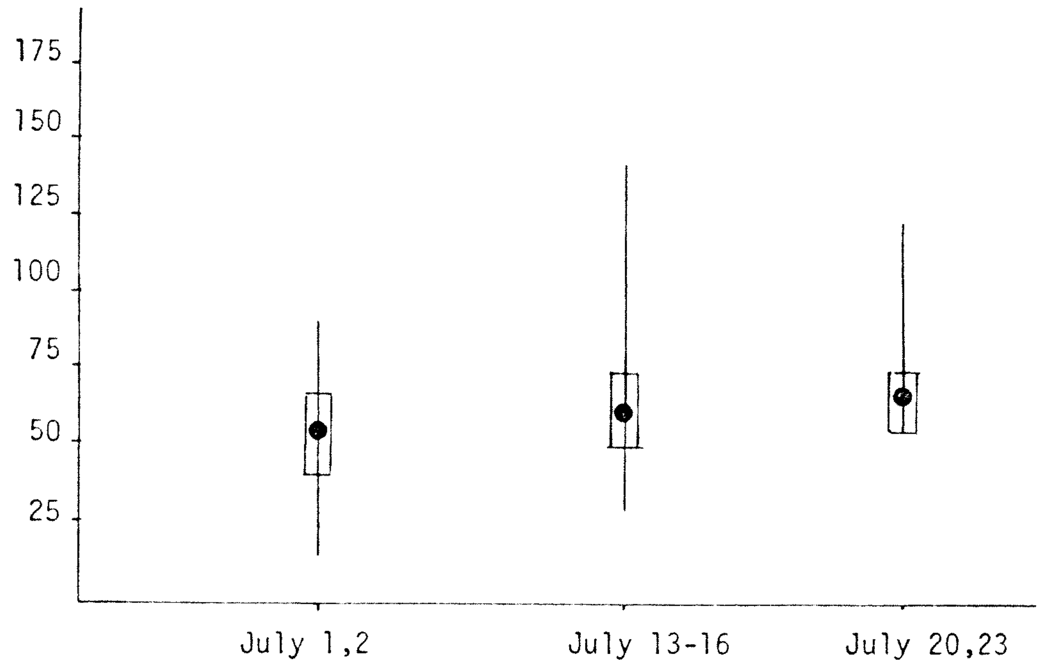


Fig. 5.05. Mean lengths reflecting growth over a four week period of brown bullheads collected from Study Site 3, MHSSA, Sierra Valley, CA, 1976.

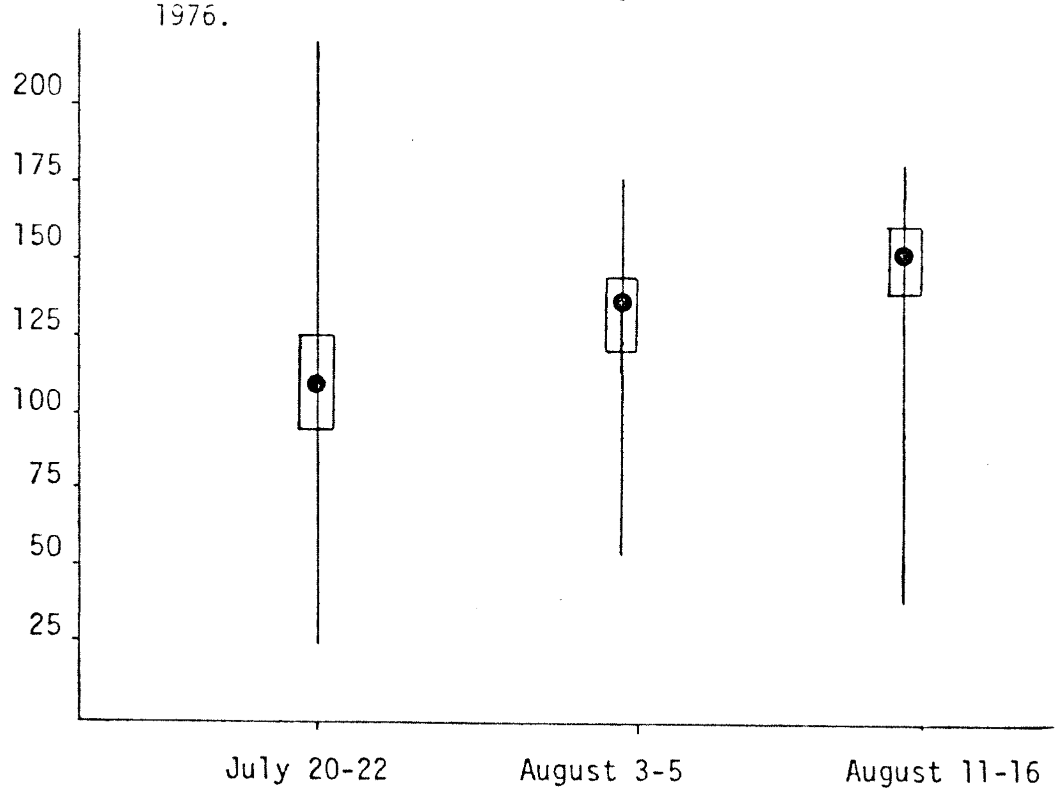
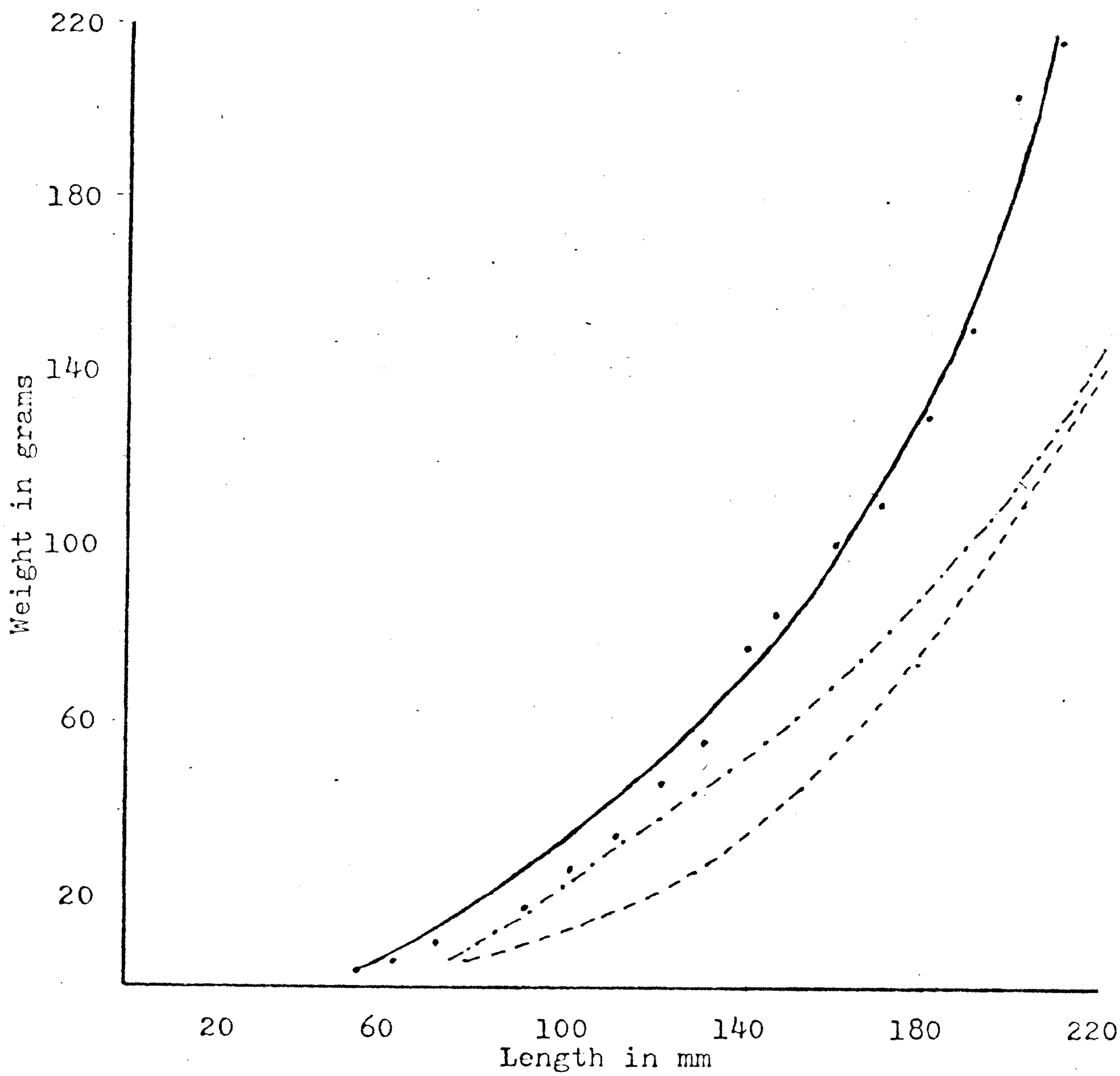


Fig. 5.06. Length-weight relationship for Ictalurus nebulosus, MHSSA, Sierra Valley, CA; June, July and August, 1976. Solid line indicates best fitting line of raw data. Broken lines indicate relationship obtained by Smith, 1939, and Langlois, 1936.



The second year-class of bullheads found in the small pools around SS3 had a mean length of 61 mm in late July. Moyle (1976) states, however, that the average length for this age class is 100 to 140 mm. The young bullheads of MHSSA are apparently smaller at age two than their counterparts found elsewhere. Moyle further states that the average length for the third and fourth year-classes is 140 to 200 mm and 190 to 280 mm, respectively. The MHSSA bullheads appear, however, much smaller than normal for only 21% and 22% of the population were over 150 mm in SS1 and SS3. Only 3.5% of the population were over 200 mm and there were only two specimens caught measuring 254 mm, the largest size recorded.

Figure 5.06 shows the MHSSA bullhead length-weight relationship in conjunction with two other curves derived from data presented in the literature. The interesting fact is the deviation that occurs between the MHSSA bullheads and the other populations at about 150 mm. It appears that the length-weight relationship is average by way of comparison only up to the size of 150 mm. Thereafter, the growth in length is conspicuously slowed.

Reproduction

Newly hatched largemouth bass were collected in SS3 from July 26th to August 9th. Their length varied from 6.4 mm to 12.7 mm (standard length). Newly hatched shiners were found in SS1 and SS3 from July 30 to August 20th. Sunfish fry were collected July 26th through August 9th; yet, they appeared in the greatest abundance after the study period, in October, at SS3. Carp fry were captured throughout June, July and August in all three study areas but predominated in SA2. Newly hatched bullheads varied from 6.5 to 12.5 mm and were collected only in SS3 from July 1st through August 20th. Bullhead fry were also seen after the termination of the study period in September and October in SS1.

No adult bass were captured and a fecundity determination was, therefore, not made. Seventy-six brown bullheads were collected from SS1 and SS3 and a subjective determination of their reproductive status was made based upon the appearance of the gonads. This information is shown in Table 5.04 where the bullheads are subdivided into three size-classes upon this subjective analysis.

Table 5.04. Observation on the reproductive status of 76 MHSSA brown bullheads collected in 1976.

Standard Length (mm)	Gonad Development
50 - 60	Undifferentiated testes and ovaries.
90 - 110	Ovaries and testes distinct but small in size and number of ova.
150 - 254	Ovaries and testes relatively large. Ovaries are vascularized.

Sexual maturity in the brown bullhead is normally reached at age three (Harlan & Speaker, 1956) when the average size is from 7.8 to 10 inches (Emig, 1966). As shown in Table 5.04, sexual maturity for the MHSSA bullhead appears to be reached at six inches or around 150 mm. Unfortunately, age determinations could not be made on these fish without undergoing a laboratory process that was beyond the scope of this project. However, we know that those fish of 150 mm are at

least three years old. Based upon the data that we do have on size reached at sexual maturity, in addition to the information presented on length, weight and growth, we might assume that the MHSSA brown bullhead is a smaller brood fish when compared with populations found elsewhere. The presence of smaller sized brood fish in conjunction with a slower rate of growth may both be indications of a fisheries system that is not in equilibrium with any or all of the following: 1) food supply; 2) breeding sites; 3) interspecific and/or intraspecific individual space requirements. The basis for this condition is generally crowding, yet, the cause of crowding may be multifaceted.

Brown bullheads generally breed from June through September (Emig, 1966). However, the MHSSA bullhead appears to breed late (August, September and primarily in October). Temperature and photoperiod are important factors controlling the reproductive rhythms of certain fishes which spawn seasonally (Hoar, 1957), as does the MHSSA bullhead. Consequently, the variation from the established norm is to be expected. Since the spawning period is late, we may assume that this is the cause for the slow rate of growth for young bullheads.

Diet of the Brown Bullhead

Of the 76 bullheads taken from the MHSSA, only 20 were utilized in an investigation of the food habits of this species. Of these 20, the data from only 19 will be presented here. The stomach matter was first divided into plant and animal categories. All organisms were then identified to order. Although some items were identifiable to a more specific taxonomic level than order, most were not. Thus the order was the lowest taxonomic level that we could use and obtain a consistent analysis by number and frequency of occurrence. Use of this rather broad category insured that slightly digestible matter would not be given more importance over matter that was readily absorbed.

For purposes of analysis, all food items were grouped into one of 11 categories: 1) algal mass; 2) odonates; 3) amphipods; 4) ephemerops; 5) chironomid larvae; 6) molluscs; 7) corixids; 8) chironomid pupae; 9) beetles; 10) prostigmata; 11) notonectids. Miscellaneous or unidentifiable items (pebbles, etc.) accounted for a negligible percentage by number, weight and frequency of occurrence.

Analysis by Weight

In an analysis of food habits by weight (Table 5.07), plant materials appeared to be the most important food item for all bullheads, for they comprised 60% of the total stomach contents. Odonates contributed 22.7%, the second most prominent food item. Amphipods comprised 8.4% by weight of the total stomach contents.

Analysis by Number

This type of analysis considers the animal contents in the stomach without regard to the importance that plant materials might play (these materials could not be counted without the risk of duplication of effort thus distortion of results). Because of this bias, a numerical analysis does not illustrate the true importance of all individual materials consumed and cannot in anyway reflect food habits. However, when considering the animal contents alone, it is elucidating to know which are the invertebrates that are consumed in the greatest number. Odonates comprised 37% and ephemerops 18.8% of the total stomach contents (Table 5.07). Molluscs accounted for only 10.3% of the stomach contents by number yet their food value is uncertain relative to the other items.

Table 5.05. Summary of food items for MHSSA bullheads greater than 150 mm standard length, Sierra Valley, CA, 1976. (n = 6)

Item	Number*	Weight*	Freq. of Occurrence*	Number+	Weight+	Freq. of Occurrence+
Algal mass	—	86.8	100	—	1	1
Odonatea	34	6.6	57.1	2	2	3
Ephemeropterans	23.4	0.91	57.1	3	5	3
Chironomid larvae	20.6	0.8	71.4	5	6	2
Molluscs	7.0	1.5	28.6	5	4	5
Corixids	3.6	0.55	57.1	6	7	3
Chironomid pupae	1.42	0.8	14.3	7	8	6
Coleopterans	0.71	—	14.3	8	9	6
Amphipods	9.22	1.79	42.9	4	3	4
Sample Size	141	1.82				

Table 5.06. Summary of food items consumed by MHSSA bullheads less than 150 mm standard length, Sierra Valley, CA, 1976. (n = 13)

Item	Number*	Weight*	Freq. of Occurrence*	Number+	Weight+	Freq. of Occurrence+
Algal mass	—	13.6	16.7	—	3	6
Odonates	38.5	50.6	66.7	1	1	2
Ephemeropterans	16.4	4.4	58.3	2	5	3
Chironomid larvae	10.5	2.75	91.7	5	6	1
Molluscs	13.7	5.6	50	4	4	4
Corixids	2.53	2.5	50	6	7	4
Chironomid pupae	0.54	0.95	25	7	8	5
Coleopterans	0.18	—	8.3	8	—	7
Amphipods	15.4	20.0	91.7	3	2	1
Sample Size	692	1.053				

Table 5.07. Summary of food items consumed by all sizes of MHSSA bullheads, Sierra Valley, CA, 1976. (n = 19)

Item	Number*	Weight*	Freq. of Occurrence*	Number+	Weight+	Freq. of Occurrence+
Algal mass	—	60	47.5	—	1	6
Odonates	37	22.7	63.2	1	2	3
Ephemeropterans	18.8	2.2	58	2	5	4
Chironomid larvae	10.4	1.5	84	4	6	1
Molluscs	10.3	3.0	37	5	4	7
Corixids	2.2	1.3	53	6	7	5
Chironomid pupae	0.6	0.09	21	7	8	8
Coleopterans	0.2	—	10.5	8	9	9
Amphipods	11.6	8.4	74	3	3	2
Sample Size	837	2.873				

* Percentage
\+ Rank

Fig. 5.07. Percent composition by frequency of occurrence of plant and invertebrate material in stomach contents of two size-classes of _Ictalurus nebulosus_, MHSSA, Sierra Valley, CA, 1976.

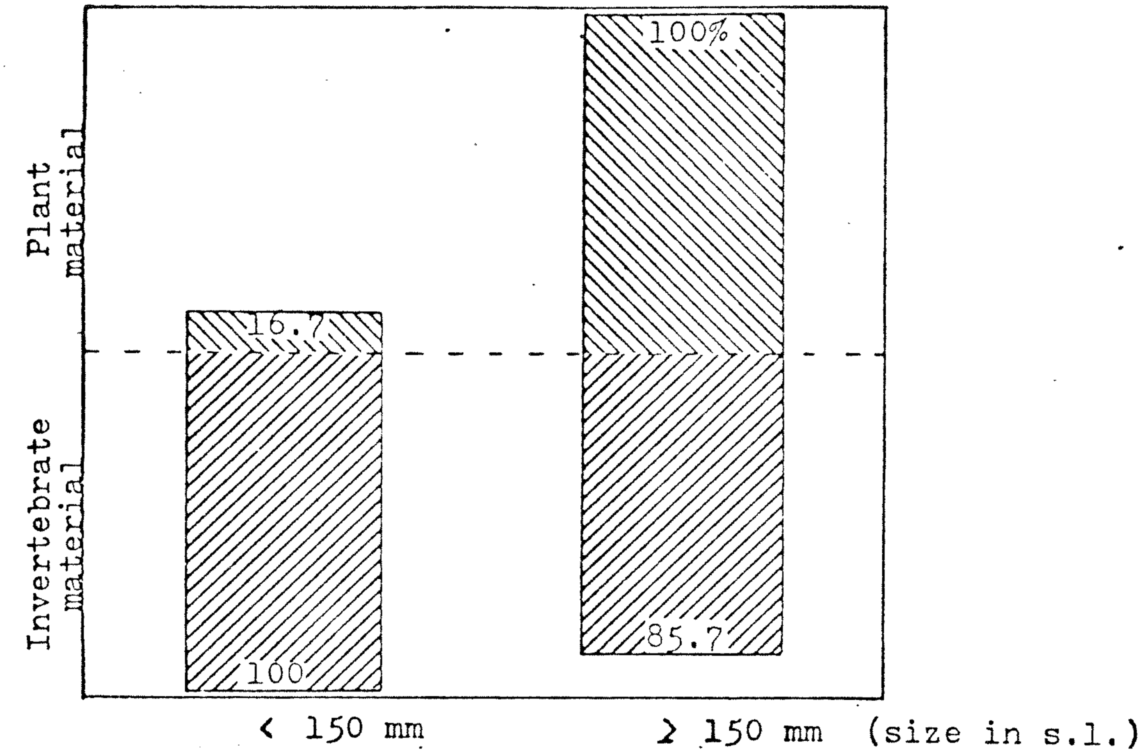
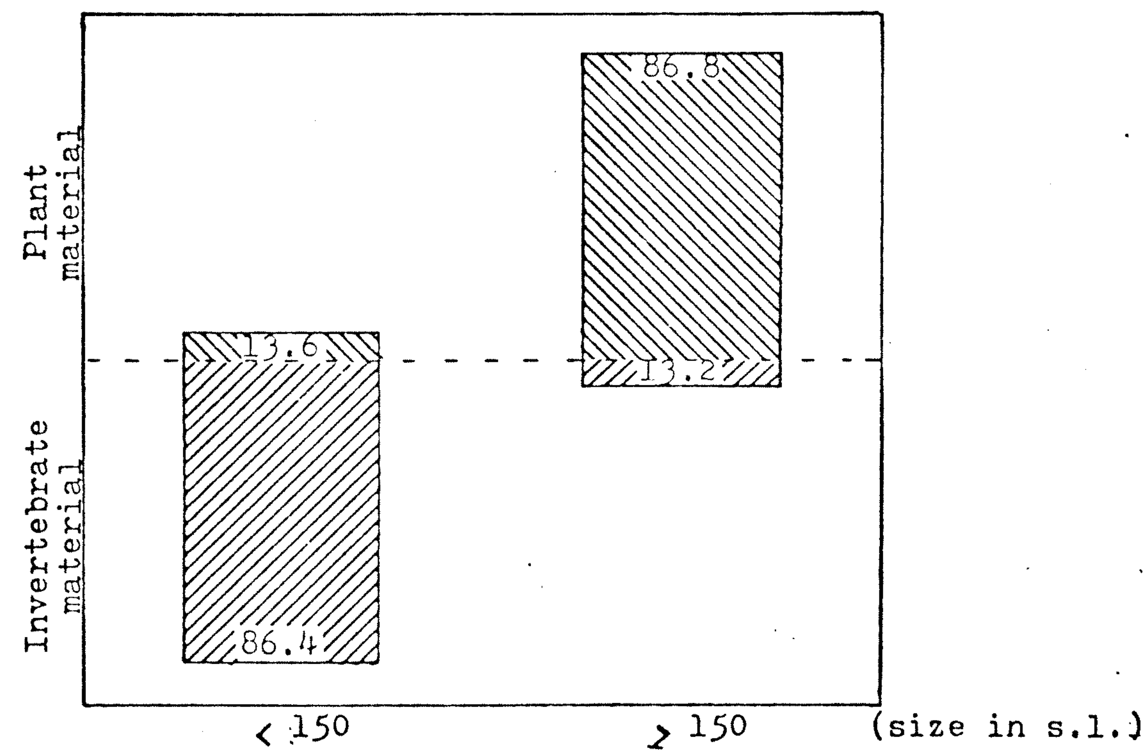


Fig. 5.08. Percent composition by weight of plant and invertebrate material in stomach contents of two size-classes of _Ictalurus nebulosus_, MHSSA, Sierra Valley, CA, August and September, 1976.



Analysis by Frequency of Occurrence

Analysis by frequency of occurrence reveals that chironomid larvae were the dominant forage at 84% of all the stomachs counted. Plant material comprised 47.5% and amphipods 74%. Sixty-three percent of the stomachs contained odonates and 58% contained ephemerops. Molluscs were found in only 37% of the total stomachs analyzed (Table 5.07).

Analysis by Size-Class

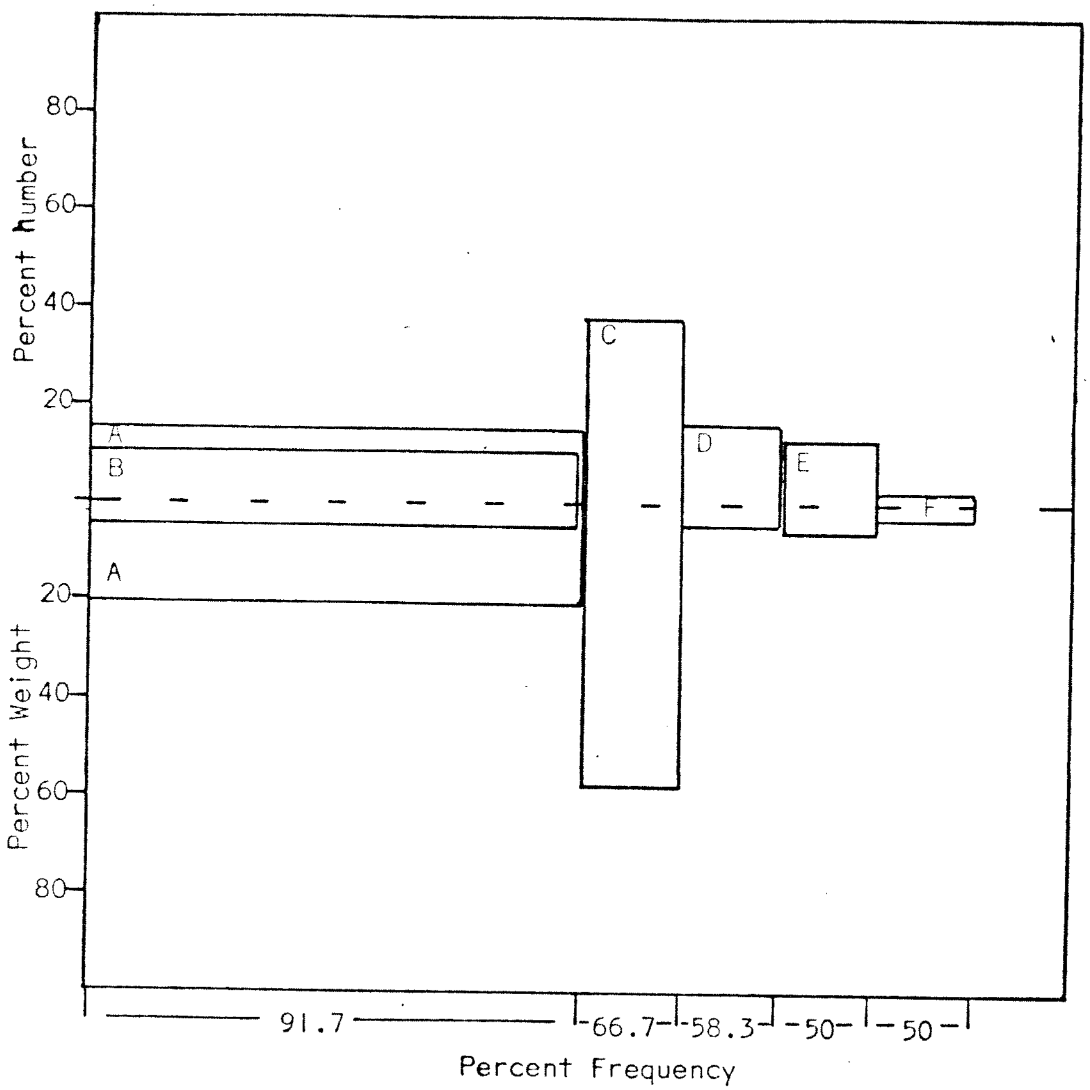
Based upon the findings reported earlier concerning length, weight and growth as well as reproduction, there appears to be a significant change in the physical and behavioral characteristics of the bullheads around 150 mm standard length. In an effort to ascertain whether or not this distinction was also represented in food habits, the stomachs were divided into two classes: those greater than or equal to 150 mm and those less than 150 mm. The results proved most interesting and seemed to further support the earlier distinctions. Plant materials comprised 100% by frequency of occurrence and 86.8% by weight in those stomachs taken from bullheads longer than 150 mm (Table 5.05, Figure 5.10). However, for those bullheads of a smaller size, the plant material was only present in 16.7% of the stomachs and comprised only 13.6% of the total weight (Table 5.06, Figure 5.09).

A chi-square 2x2 contingency test was run between the two size-classes and the raw data from weight of animal matter versus plant matter. The difference was highly significant ($p \leq .01$) as was the difference when the frequency of occurrence of animal matter versus plant material was compared for these two size-classes.

The food habits study of I. nebulosus was undertaken to elucidate the ecological relationships that exist in the food chain and the size-class distinctions in diet. In addition, we hoped to obtain indications of the health of the fisheries system by comprehending the food role that these bullheads play and the requirements that they have for the maintainance of their present condition. The literature states that the bullheads forage most actively at night yet we found them taking bait most readily during the day during our hook and line sampling. However, our best trap results were when the traps were left over night, indicating that this was in fact their period of greatest activity. The bullhead is reported to be primarily a bottom feeder (Harkin & Speaker, 1956; Cable, 1928; Simpson, 1951) feeding on detritus, algae, insect larvae and molluscs. The fry in Columbia Lake, Connecticut (Raney & Webster, 1940) were found to consume chironomid larvae and zooplankton. This appears to be consistent with data obtained in other studies (Moore, 1922; Sibley, 1929). Adults, however, are considered to be omnivorous, foraging on a variety of foods ranging from fish, molluscs and insect larvae to algae (Forbes & Richardson, 1920; Jepson & Platts, 1959).

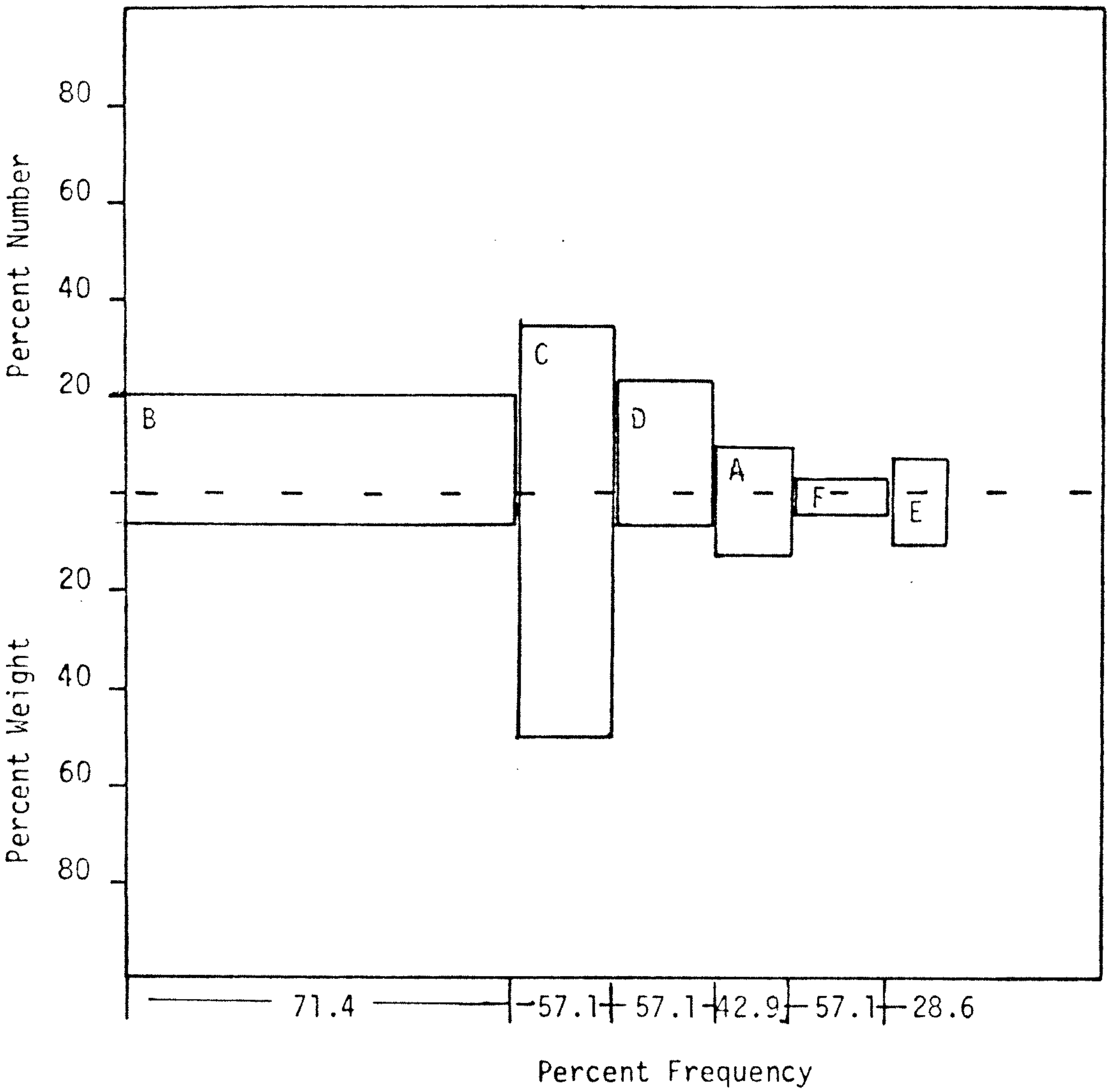
The literature indicates that the food habits of the brown bullhead found in the MHSSA are consistent with bullhead food habits found elsewhere. However, as the bullheads from the MHSSA attain sexual maturity at a much later date than the average found elsewhere, it appears that when considering the contributions made to the diet of this fish, insect larvae are unusually important for an extended period of time. Any factor serving as a detriment to the larval insect population would, therefore, have an equally severe effect upon the population of brown bullheads.

Fig. 5.09. Percent composition by major food categories in number, weight and frequency of occurrence for Ictalurus nebulosus less than 150 mm (s.l.), MHSSA, Sierra Valley, CA, August and September, 1976. Data reflect total exclusion of plant material found in stomachs.



A. Amphipoda
B. Chironomidae larva
C. Odonata
D. Ephemeroptera
E. Gastropoda
F. Corixidae

Fig. 5.10. Percent composition by major food categories in number, weight and frequency of occurrence for Ictalurus nebulosus greater than 150 mm (s.l.), MHSSA, Sierra Valley, CA, August and September, 1976. Data reflect total exclusion of plant material found in stomachs.



A. Amphipoda
B. Chironomidae larva
C. Odonata
D. Ephemeroptera
E. Gastropoda
F. Corixidae

SUMMARY

Although eight species of fish were collected, greater than 50% of the individuals at any one sample site consistently fell within the confines of only one species. Such a pattern may indicate a stressful environment.

The most abundant fish was the brown bullhead, *Ictalurus nebulosus*; yet its absolute dominance was achieved only in the waterways having a comparatively reduced vegetation, and a substrate with some sand and a moderate to sluggish waterflow. The carp, *Cyprinus carpio*, was found in densities inversely correlated to the conditions preferred by the brown bullhead. The one game fish found in abundance was the largemouth bass, *Micropterus salmoides*. The abundance of this fish was directly correlated to a high density of forage fish, *Notemingonus crysoleucus*, and a corresponding low density of aquatic vegetation. Game fish were not found in areas where water level fluctuation was greater than 100 cm and where the substrate was without sand or gravel.

An unusual weight-length relationship was found in specimens of brown bullheads greater than 150 mm, where they proved to be shorter at any given weight than those reported in the literature. They also became reproductively mature when relatively short. The overall impression is of a population of fish experiencing some type of environmental stress, and expressing it in growth and maturation abnormalities.

CHAPTER 6
AMPHIBIANS AND REPTILES

INTRODUCTION

The amphibian and reptile study was carried out by one person. Efforts were concentrated on collecting basic population data since taxonomic problems were minimal; only one amphibian (the bullfrog, *Rana catesbeiana*) and one reptile (the common garter snake, *Thamnophis sirtalis*) were found in the Marble Hot Springs Study Area.

METHODS

Schedule

The first three weeks of field work, 7 through 27 June, consisted primarily of searching for amphibians and reptiles. During this time, 44 hours were spent in the field. Of these, 28 were before noon, 11 were after noon and before sunset, and five were after dark. Many different habitats were searched, including sagebrush, salt flats, wet meadows, ditches, channels and roadside vegetation. Rocks and wood lying on the ground were turned and vegetation was parted where it was thick (sage, roadside bushes and tules) when looking for animals. Open areas were simply walked. Waterways were inspected from shore and while wading through them.

Bullfrogs and Common Garter Snakes were noted when seen and caught when possible. No other amphibians or reptiles were found; the following nine weeks of field work concentrated on these two species, while attempts to find others continued.

The typical schedule for field work for the weeks 28 June through 28 August, included field work all day Monday (0700 to 1930 hours), late afternoon and evening work Wednesday (3-5 hours plus sleeping in the field), and morning work Tuesday, Thursday and Friday (3-5 hours each). Frequently one morning a week was skipped. Ten to fifteen hours a week were spent at the Sierra Nevada Science Field Campus caring for live animals brought back from the field for observation, preparing specimens (road kills or other animals found dead), dissecting female snake specimens to look for young, and organizing field notes.

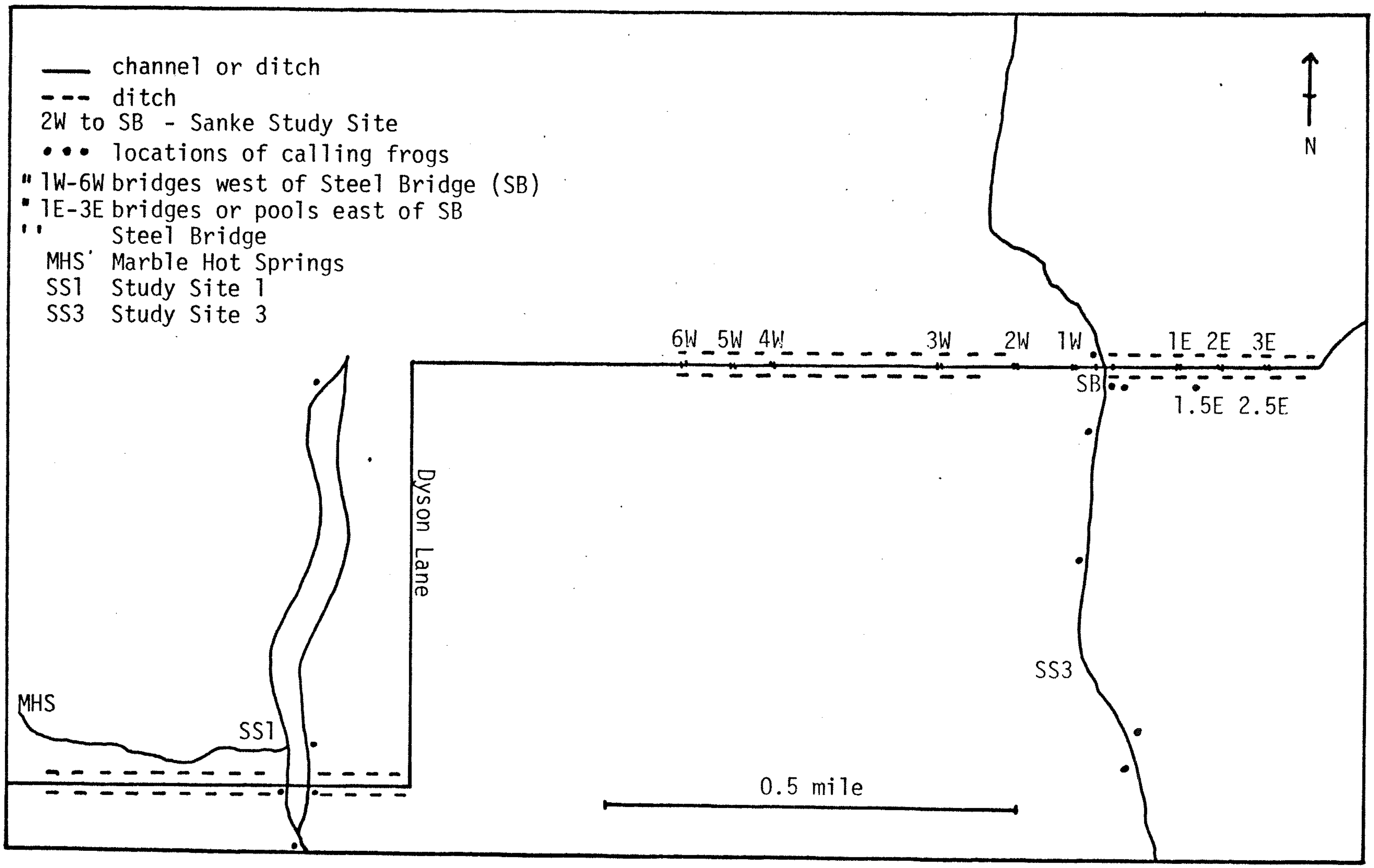
Bullfrogs

Frogs seen in the water with 7X50 binoculars from the first bridge west of the steel bridge (1W) were counted on the quarter hour (0815 to 1515 hours) on 5, 12, 19, and 26 July and on 3 and 10 August. Frogs at the second bridge west (2W), the first, second and third bridges east of the steel bridge (1E, 2E and 3E, respectively) and at a pool between 1E and 2E (1.5E) were also counted once in the morning on the same dates (Figure 6.01). Frogs seen while carrying on other field work were also noted.

A few times during the summer I tried to catch frogs with a long-handled (1.7 m) dip net (22X47 cm). They were almost impossible to catch; they dived down into the water from the surface when I was still three to five meters away. The few caught in nets or accidently in minnow traps and those found dead were measured to the closest half-centimeter with a meter tape or calipers.

At least two hours a week were spent listening for frogs after dark. The time and approximate location of calling frogs were noted. Frogs that I heard at other times of the day (especially on Mondays) and those heard by other

Fig. 6.01. The amphibian and reptile study area showing the small bridges, places sampled for tadpoles, locations of bullfrogs heard calling, and the Snake Study Site; MHSSA, Sierra Valley, CA, 1976.



members of the research group were also noted.

Tadpoles were trapped in unbaited minnow traps (for dimensions see Chapter 5: Methods) at Study Site 1 (SS1), Study Site 3 (SS3), 1W, 1E, and 1.5E, from 23 to 29 June and 12 to 16 July. In mid-August tadpoles at 1W, SS1 and SS3 were trapped. Traps were left out overnight for one or more nights.

A few tads were caught with the long-handled dip net in June and July at 1W and 1.5E. In August tads were dipped at 2W, 3W, 4W, 5W, 6W, 2E, 2.5E, SS1 and SS3 (Figure 6.01). The total length, measured to the closest half-centimeter with a meter tape or calipers and the number of legs of many tadpoles were recorded.

Tadpole population sizes were estimated in August at 2W, 2E and 2.5E (a pool formed between 2E and 3E when water in the roadside ditch dried up). Tadpoles were caught with a dip net, marked by clipping the dorsal fin with scissors 2 cm forward from the tip of the tail and released. Recapture, with net, was carried out within a few days.

Common Garter Snakes

A snake study site (SSS) was chosen along 135 m of the dirt road, Dyson Lane, immediately west of the steel bridge, because of the concentration of snakes there (Figure 6.01). Snakes seen while walking along the north and then south edges of the road were counted and mapped hourly (0700 to 1900 hours) once weekly. No attempt was made to catch snakes on these days so as not to disturb their normal activity. The snakes concealed themselves in bushes and even short grass; care was taken to note as many individuals as possible.

Two or three mornings of the week were spent catching and marking snakes. Snakes were caught with bare hands or by stepping lightly on their tails. Much data were collected for each individual. Total length and tail length were measured to the closest centimeter with a meter tape. The sex of most individuals was determined. Females have tails that are obviously constricted beyond the vent. In males, the tail tapers to a point more gradually. Other characteristics such as scars, notches in belly scutes, extra blotches of color (orange or black) on the venter, and the number of upper labials and post oculars on right and left sides of the head were noted. These data were used for individual recognition for the extent of the summer.

Three rings of fingernail polish of six possible colors were used to mark the tail of each individual every time it was caught. Thus, Red-Blue-Yellow, as read from anterior to posterior, was the name applied to the snake with those bands. These marks were helpful in compiling data on the behavior of individual snakes since individuals could be identified from a distance without disturbing their activity. A polish-marked individual was not caught unless a meal could be seen as a conspicuous bulge in its body. In this case, information on the food eaten was desired. The polish marks usually lasted two to three weeks.

In order to accumulate information about what these snakes ate, I attempted to force many snakes to regurgitate their meals. A snake was held by the tail with one hand while the other hand moved forward along the ventral surface, the thumb pressing constantly into the belly, until it regurgitated food or until I believed it had no food to regurgitate.

The population size of snakes in the SSS was estimated weekly using mark-and-recapture procedures, as described by Cox (1976). For single mark-and-recapture estimates, snakes caught one week were considered to be "marked" the

following week, so that only those individuals seen recently were used in the estimate. Population estimates were calculated weekly from 28 June through 22 August. Multiple mark-and-recapture estimates were also calculated as described by Cox (1976) from 26 July through 22 August, after enough data were compiled from previous weeks' marking. In this case, all snakes previously caught were considered to be marked.

The place and time of capture (or sighting) were recorded for each snake caught or seen throughout the summer. The location and probable cause of death were noted for all dead snakes found. Notes were taken on snakes seen hunting or moving from one place to another.

RESULTS AND DISCUSSION

Other Possible Species of Herptiles in the MHSSA

The Bullfrog, *Rana catesbeiana*, was the only amphibian found in the MHSSA in 1976. Juveniles of the Western Toad, *Bufo boreas*, and the Pacific Treefrog, *Hyla regilla*, were reported from the area on 21 July 1967 and 19 June 1969; juvenile Leopard Frogs, *Rana pipiens*, were also reported in 1967 (Mackey, unpublished notes). Bullfrogs were more abundant on 21 July 1967, when many were seen floating in the water under the steel bridge. At most, two frogs were seen there at one time in 1976.

Tim Filippini, a 25-year resident of Sierra Valley, gave me some information about the valley frogs and toads. He has seen Leopard Frogs in small numbers in the main channel, four miles south of the steel bridge, every summer through 1975. (He was not living in the valley in 1976.) Mr. Filippini believes that 1967 was the first year he saw Bullfrogs that far south of the steel bridge. Thousands of little black Western Toad tadpoles were seen once every few years, also four miles south of the steel bridge, perhaps in wet years. As many as 50 juvenile toads were seen run over by cars on one two-mile stretch of dirt road near the main channel, each time it was driven one summer in the late sixties (Filippini, personal communication).

It is not known whether a big change has occurred which might be permanently detrimental to the amphibians of the MHSSA. The year 1976 may have been just a low point in the fluctuation of population numbers. Rainfall in the years 1967 to 1970 was much higher than normal (See Chapter 2) so the amphibian populations would be expected to be high then. Perhaps the juvenile amphibians seen in the MHSSA in the late sixties had migrated there from breeding grounds elsewhere.

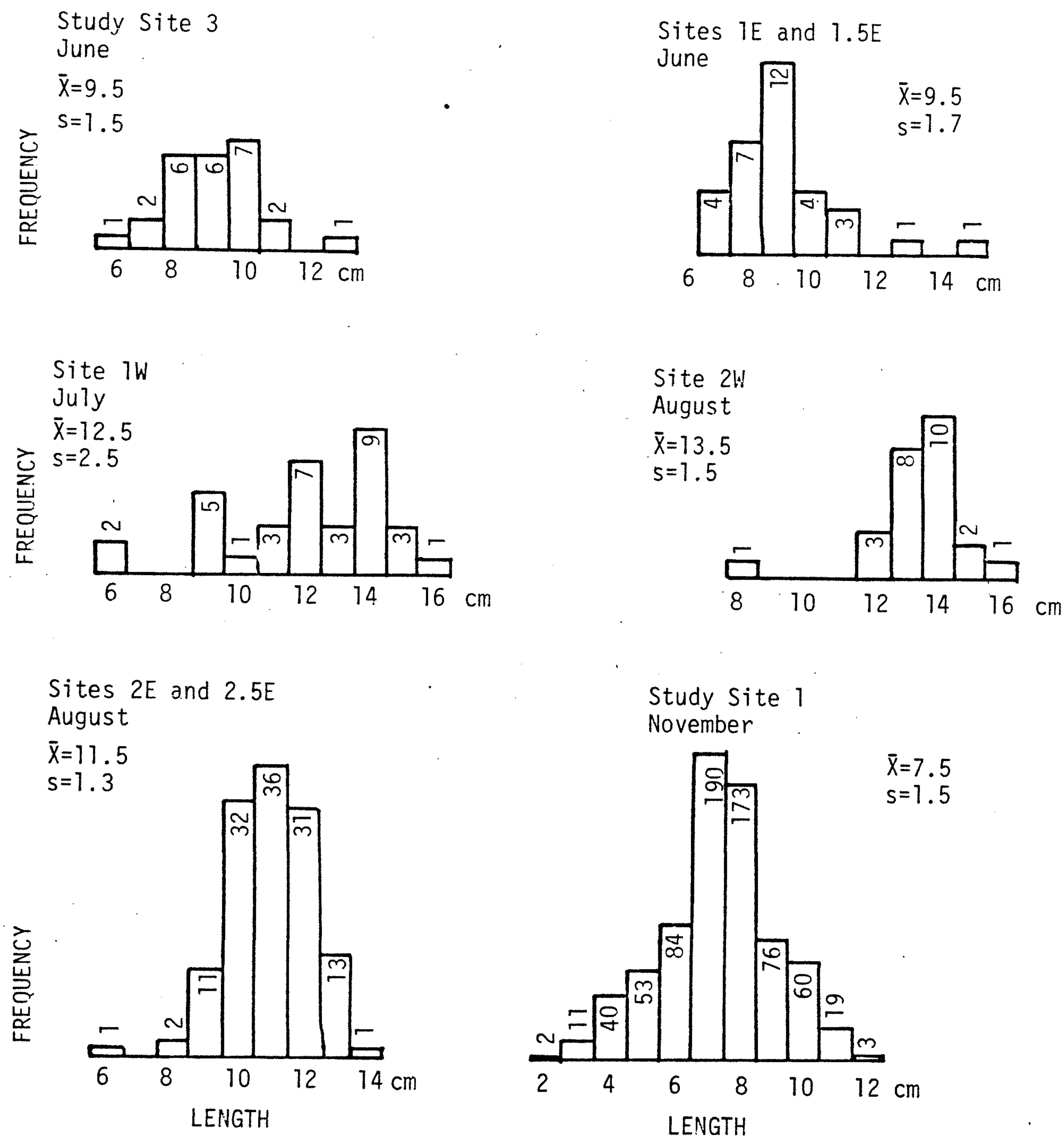
The only reptile found in the MHSSA was the Common Garter Snake, *Thamnophis sirtalis*. Gopher Snakes, *Pituophis melanoleucus*, were seen along Route A23, quite near, but not in the marsh. The Western Rattlesnake, *Crotalus viridis*, was reported by valley residents to be found in the foothills surrounding the valley.

Bullfrogs

Growth

Tadpoles were caught with minnow traps and dip nets throughout the summer and measured to the closest half-centimeter (Figure 6.02). They were caught at SS3 and 1E plus 1.5E in June, 1W in July, 2W and 2E plus 2.5E in August (Figure 6.01). Mean lengths were calculated by assuming that all individuals in each centimeter-class were middle-sized for that class. (For example, it was

Fig. 6.02. Lengths of bullfrog tadpoles measured at six locations in MHSSA, Sierra Valley, CA, in June, July, August and November, 1976.



assumed that all individuals in the 6-7 cm class were 6.5 cm). The mean lengths of tadpoles caught in July and August were higher than those caught in June, but cannot be directly compared because they were sampled from different isolated areas with different water depths, amounts of food and densities of tads and fish. However, these tadpoles may have been in one continuous population prior to June. All are believed to have overwintered at least one winter because small tadpoles were not found anywhere until mid-August. Bullfrog tadpoles normally overwinter one or two winters before metamorphosing depending on location (Stebbins, 1951).

Tiny tadpoles were first found on 16 August when the ichthyologists were seining in the channel at SS1. They were about 2-3 cm long and had probably hatched quite recently. Tads caught in minnow traps there on 11 September were roughly 2-5 cm long. On 10 October small tads 2-6 cm were dipped from under the west end of the steel bridge, while on 31 October tads dipped at SS1 ranged in size from 2-10 cm. On 21 November, more than 700 tadpoles were caught in minnow traps that were left out overnight at the mouth of the Hot Springs in SS1. At this time, after about three months of growth, the mean size of these tadpoles was still below that of the tadpoles that were caught in June (Figure 6.02). The warm water of the Hot Springs probably allows faster growth than cold water; thus, by next June these tads may actually exceed the lengths of those caught last June at SS3. Growth of tadpoles at SS1 for August through November is summarized in Table 6.01.

Table 6.01. Lengths of Bullfrog tadpoles caught at SS1, Marble Hot Springs Study Area, August through November 1976.

Date	Sizes (cm)
16 August	2 to 3
11 September	2 to 5
31 October	2 to 10
21 November	2 to 12

Rate of growth for Bullfrog tadpoles over 12 months is summarized in Table 6.02, using data for the first three months of life, August through November, for one year class and data for months 10 through 12, June to August, for the previous year class.

Table 6.02. Rate of growth for Bullfrog tadpoles from birth to 12 months using data from the year classes born in 1975 and 1976 in the Marble Hot Springs Study Area.

Age (Months)	Year Class	Total Size Range (cm)	Size Range of Most Individuals (cm)
0	1976	2- 3	2- 3
1	1976	2- 5	3- 4
2	1976	2-10	5- 7
3	1976	2-12	7- 9
10	1975	6-15	8-11
11	1975	6-16*	Widespread
12	1975	6-16	9-14

* Many metamorphosed

Newly metamorphosed frogs caught in mid-July ranged from 5.0-6.0 cm in snout-vent length ($\bar{x}$ = 5.5) when measured to the closest half-centimeter (Table 6.03). Stebbins (1951) reported that length at metamorphosis for Bullfrogs may be from 4.3 to 5.9 cm, with an average of 5.3 cm.

Unlike the frogs metamorphosing in July, three juvenile frogs collected 11 November, at SS1, measured 3.5 cm. These frogs probably hatched from eggs in early August, or perhaps late July. They may have developed quickly because of warm water temperatures (35C) at the mouth of the Hot Springs, where thousands of tadpoles congregated from September to November. However, most of the tadpoles that hatched in August will probably overwinter and complete metamorphosis next summer.

Table 6.03. Length-frequency of juvenile Bullfrogs caught in the Marble Hot Springs Study Area, 1976.

Length (cm)	Frequency	
	July at 1W	November at SS1
3.5	0	3
4.0	0	0
4.5	0	0
5.0	5	0
5.5	8	0
6.0	1	0

The eight older frogs caught this summer ranged in size from 8 to 14 cm and averaged 11.5 cm (Table 6.04). Raney (Oliver, 1955) found that female Bullfrogs in New York matured at four to five years at about 12.6 cm. Perhaps the two larger females found this summer were mature.

Table 6.04. Lengths of adult Bullfrogs caught in the Marble Hot Springs Study Area, Summer 1976.

Males: Lengths (cm)	Females: Lengths (cm)
11.5	8.0
12.0	10.0
12.5	12.0
14.0	12.5

Numbers of Tadpoles

The numbers of tadpoles in three isolated ponds were estimated in mid-August, using a mark-and-recapture procedure. Unfortunately these estimates were not very precise (Table 6.05). Estimates, even with this limited accuracy, were possible only because the tadpoles were concentrated after most of the water in the roadside ditches dried up. In wetter years when the ditches retain water all summer, estimates of population densities would be almost impossible. Even this year, population estimates of tadpoles in pools under other little bridges could not be carried out because so few (less than five) tadpoles were caught

at one time when netting or trapping.

Table 6.05. Population estimates of Bullfrog tadpoles from three isolated pools in the Marble Hot Springs Study Area, August 1976.

Location	Dimensions (m)	No. Marked	No. Recaptured / No. In Sample	Population Estimate	Confidence Limits 75%	95%
2E	15 X 5	52	4/48	624	433-866	299-8666
2.5E	7 X 7	70	18/112	435	307-760	368- 538
2W	15 X 5	10	1/17	170	81-	59-

The tadpoles sampled at 2E and 2.5E could have been spread out along the roadside ditch from the steel bridge to 2.5E earlier in the summer. Because many tadpoles died as the water receded, many more than the estimated numbers of tadpoles were present earlier in the summer. Likewise, many more than that number would have survived if the water had not receded.

In late October the water at 2W completely dried up. I counted more than 100 dead tadpoles there on 29 October. One dry mud-caked tadpole was regurgitated by a snake then, at my insistence. I do not know how many other dead tadpoles had been eaten by snake or bird predators, before I counted the remaining ones. Perhaps the population estimate of 170 was not far off (Table 6.05).

Time of Metamorphosis

All juvenile frogs seen from 1W with 7X50 binoculars were counted once weekly (5 July to 10 August) on the quarter hour (0815-1615 hours). Significantly more newly metamorphosed frogs were seen on 5 and 12 July (average 13 and 14 per hour, respectively) than on 19 July (average 5 per hour). Also, significantly more young frogs were seen on 19 July than on 26 July and 3 and 10 August (average 1 to 2 per hour) (Table 6.06). Random Block Design Analysis of Variance (RBDAV), time of day vs. date, was used to analyze the data. After 10 August, counts were discontinued because so few frogs were seen (one or two at a time). A similar but unquantified decrease was noted at 2W between 19 July and 3 August. Frequently 15 to 20 frogs were seen at 2W in the morning until about 19 July. By 3 August it was hard to find any. The disappearance of these frogs may have been related to any of several factors. They may have been more subject to predation and/or dessication as frogs because they spend more time at the surface of the water, or they may have moved to the main channel where there was more water.

I do not think that many frogs metamorphosed later in the summer because so few tadpoles had four legs, a necessary prerequisite (Table 6.07). The "tadpoles" at 1W that had four legs were counted as juvenile frogs in the frog counts because little frogs without tails could not always be distinguished from those with tails left to absorb.

Table 6.06. Seasonal and daily activity of juvenile Bullfrogs, as measured by the number of frogs seen from 1W, MHSSA, 5 July through 10 August, 1976.

Time (hrs)	5 July	12 July	19 July	26 July	3 August	10 August	$\overline{X}$
0815	19	16	6	1	2	0	7.3
0915	24	20	12	4	2	6	11.3
1015	21	17	5	3	3	4	8.8
1115	10	12	4	3	3	0	5.3
1215	11	14	8	4	0	0	6.2
1315	12	7	3	0	1	1	4.0
1415	6	15	4	1	1	1	4.7
1515	6	13	1	1	1	3	4.2
1615	11	17	6	0	0	2	6.0
$\overline{X}$	13.3	14.6	5.4	1.9	1.4	1.9	

Table 6.07. Numbers of Bullfrog tadpoles with 0, 2 and 4 legs in MHSSA, Summer, 1976.

Location	Date	0 Legs	2 Legs	4 Legs
1W	13-20 July	10	14	17
	19-23 August	0	10	0
2W	12-23 August	5	17	3
SS3	24-28 June	16	9	0
	14 July	1	5	0
1E & 1.5E	24-28 June	9	25	0
	13-16 July	14	9	0
2E & 2.5E	14-19 August	65	39	0

Daily Activity of Juvenile Frogs

Significantly more young frogs were seen from 1W at 0915 hours, than at any other time of the day (0815-1615 hours), 5 July to 10 August, as determined by RBDAV, time of day vs. date (Table 6.06). An average of 11.3 frogs were seen at 0915 hours, compared to 7.3 at 0815 and 8.8 at 1015. From 1115 hours on, averages of 4-6 frogs were seen. These frogs are probably at the surface of the water in the morning for the purpose of warming up in the sunshine. Then they can carry on activities, such as feeding and digesting, at temperatures above the water temperature.

Density of Breeding Males

No more than two male Bullfrogs were heard from the vicinity of the steel bridge in June. However, four frogs were frequently heard during most of July.

Stebbins (1951) reported that Bullfrog males may establish croaking posts and that individuals may be found in favored places repeatedly when the population level is not great. This is what I observed from the steel bridge. The four individuals heard there called consistently from the same spots (Fig. 6.01) for weeks. When one started croaking, I anxiously awaited the others, hoping that each would let me know that he was still alive.

The 26th of July marked the first Monday that no frogs were heard from the steel bridge; indeed no frogs were heard there after that date. I found one individual at the edge of his pool one week later; he had been dead some time as he was quite dry. His legs were crushed as if he had been grabbed by a large bird. I do not know if the other frogs met similar fates, moved away, or just stopped calling. One day in August, a fisherman told me that a huge Bullfrog was sitting on the bank, north of the bridge. This was probably my old friend who called from that location in July.

Frogs were noted calling from the vicinity of SS1, during much of the summer. Two frogs were heard there from June until the end of August (when official field work ended). In July two or more additional frogs were also heard from SS1. Locations of all males heard calling are mapped (Figure 6.01).

No frogs were heard calling anywhere in the MHSSA on four weekend trips in the fall (11-13 September, 8-10 and 29-31 October and 20-21 November). Thus, the best time of the year to census calling Bullfrogs might be early to mid-July. Livezy and Wright (1947:190) reported that Bullfrogs breed in June and July in northern areas, so the peak time of calling at MHSSA correlates fairly well with that.

No particular time of day was determined as best for hearing frogs, but morning and late afternoon seemed to be as good or better that nighttime. The frogs did not call continuously; many minutes or even hours might go by without hearing any. Smith (1934:484) reported that Bullfrogs call three or four times in six to eight seconds, are silent for about five minutes, and then call again —when they are calling enthusiastically. The frogs at the steel bridge did not follow this pattern. On 19 July from 0900 to 1230 hours, one individual called much less frequently than every five minutes (15-30 minutes), but called 10 to 20 times each time it called. Frequently a frog called only once, and very sporadically. Perhaps they were not in peak reproductive condition.

Mortality of Tadpoles

Tadpole mortality was particularly evident in roadside ditches and pools as the water dried up. Dead tadpoles were seen floating on the surface, their skin eaten away by their siblings. I have observed tads chewing on other dead or dying tadpoles in the lab. Usually they eat only the epidermis, leaving a gray body the shape of a tadpole. There were probably many dead tadpoles which did not surface, as many of the tads which die in the lab do not rise to the surface.

The mortality of tadpoles probably increased as the water drying up concentrated them, possibly due to one or more of the following: 1) a decrease in the available oxygen per animal, 2) a decrease in food available per animal, 3) an increase in concentration of parasite and disease organisms, and 4) an increase in predator efficiency with the increased concentration of prey. For example, at 2.5E virtually no plant life was found in August. I cannot imagine what the tadpoles might have been eating, except other dead tadpoles. In early October, this same pool was clogged with green algae, so perhaps plant life was available

often enough to keep some tadpoles alive. Snake predators were taking a toll by early October, however. I watched one snake catch and eat three tads in rapid succession, and another snake eat one tad. Both snakes might have eaten more if I had not disturbed them. By late October, the pool had shrunk from about 7 X 7 m to 1 X 1 m. At this time many dead tadpoles were found in the water. Perhaps the most probable causes of death were lack of oxygen and/or disease. Even in August, many tadpoles at this pool had red blisters on their tails and traces of blood showing in their bellies. This may indicate a bacterial infection (Meyer and Hoffman, 1976). Many tadpoles were found with one or more anchor worms imbedded in their sides where the tail attaches to the body; these external parasites are adult copepods (Meyer and Hoffman, 1976). At 2W many tads died of dessication, if nothing else got them first, when the water dried up completely.

Mortality of Frogs

Of the five dead adult frogs that were found, two were found in commercial minnow traps (for description of traps see Chapter 5: Methods); one had its legs cut off, one had slightly mangled legs, and one had a crushed lower jaw. The frogs found in minnow traps probably drowned in the excitement of being caught. The one with no legs was probably killed by a human, hunting frogs for their delicious legs. The frog with the crushed jaw, and the one with mangled legs were probably caught by and escaped from avian predators, such as Bitterns.

One dead juvenile frog, with tail, apparently was regurgitated by a garter snake and was found near 1W in late August. These snakes do eat young frogs.

The three small juvenile frogs found at SS1, near the mouth of the Hot Springs, had little red aquatic mites covering their snouts. These mites are free living as well as parasitic, as they are seen swimming in the Hot Springs and in the channel at SS1. All three little frogs seemed to be very weak, and died in the lab 3-10 days after they were collected (11 November). In addition, one large male was hit with buckshot from a shot gun. It escaped the human predator by diving into the water before it was retrieved, but may have died later.

Common Garter Snakes

Description

All snakes found belonged to the subspecies of Common Garter Snake known as the Valley Garter Snake (*Thamnophis sirtalis fitchi*). All individuals had the same basic color pattern, with minor differences in intensity of red pigment and extent of small blotches of orange or black on the venter. The snakes had a black background color on the dorsal surface which was interrupted by a yellow mid-dorsal line, red blotches on the sides, and light stripes on the second and third scale rows up from the venter. The underside was bluish-gray (except in young individuals which had very yellow venters and were occasionally lightly spotted with black or orange, especially on the tail). Lateral stripes on the edges of the venter extended up onto the first scale row, and were brownish-gray in color.

About 65% of the snakes had seven upper labials, as is typical of the species (Stebbins, 1966). About 10% had eight upper labials, and 25% had seven upper labials on one side and eight on the other. The number of post oculars was also variable: 75% of the individuals had 3, 20% had 3 on one side and 4 on the other, and 5% had 4 post oculars.

Habitat

The snakes in the marsh depend on waterways in which to hunt. The importance of water to these snakes can be illustrated by the fact that not one snake was found more than 50 m from water, even though many of us spent time traversing sagebrush, salt flats and other dry grassland habitats. The other important component of the habitat seemed to be cover. Snakes were rarely seen along waterways where no bushes, rock walls, big holes or bridges were found. Indeed, one of the first facts I discovered was that snakes were found easily at the little bridges along the road (3W, 4W, 5W, 6W, 1E, 2E, and 3E) where they could slip between the brick-like cement pilings reinforcing the roadbed. On the Snake Study Site (SSS), immediately west of the steel bridge (Figure 6.01), the rock retaining wall, the Belding Ground Squirrel burrows and the many bushes (willow, sage, and rabbitbrush) seemed to supply additional good cover so that the snakes were not concentrated at 1W and 2W. It is my belief that the snakes were concentrated along this 135 m of road because of the excellent cover and availability of aquatic food.

Carpenter (1952) found that the Common Garter Snake, in a Michigan marsh area, was found only infrequently in wet areas, spending more time on open hillsides and pastures. This apparent preference for drier habitat might be partially explained by competition with <u>Thamnophis s. sauritas</u>, the Ribbon Snake and <u>T. butleri</u>, Butler's Garter Snake, both of which were found to be more aquatic than <u>T. sirtalis</u>.

The snakes in the MHSSA were definitely well acquainted with the immediate areas in which I found them. Frequently I tried to catch one snake several times at one particular spot to which it returned. It used the same ground squirrel burrow or crevice between the rocks each time in escaping. Carpenter (1952) also reported that garter snakes are familiar with escape routes. He and I independently observed that snakes "knew" that bushes were good places in which to hide, and that they would even pass between the legs of a person in order to get to one. In fact, some snakes seemed to be caught off guard when I grabbed them as they lay under bushes or in holes. They probably have no predators that find them when they are thus concealed.

Cover may not be as important in escape from predators as it is for behavioral thermoregulation. On 31 October I carried out temperature "regulation" tests with a freshly dead snake which was found that morning imbedded in a thin layer of ice at the edge of a pond. When laid out in the mid-day sunshine, the snake's cloacal temperature, measured with a quick reading Schultheis thermometer, rose 2C per minute at first, slowing to 1C per minute after attaining a temperature of about 20C. As the temperature approached the maximum possible, 36C under these conditions, it changed very slowly. When placed in shade or in cold water (12C or 4C, respectively), the body temperature dropped more quickly than it had risen. Thus, to maintain the preferred body temperature (20-30C as reported by Carpenter, 1956) a snake might have to move in and out of sunshine frequently.

Food Habits

Although snakes were found in large numbers from 11 June on, only one animal was found to have eaten before mid-July. Carpenter (1952) reported that it was several weeks after emergence from hibernation before frequent feedings were apparent in a population of Common Garter Snakes in Michigan. It seems likely that the same was true of this population. Most of my observations of hunting and

most successful forced regurgitations occurred in August and on a weekend trip in September.

No snake was ever successfully forced to regurgitate a meal that was not evident as a distinct bulge before attempts to force regurgitation were begun. In fact I felt that I injured some individuals that did not have meals to regurgitate. At least two individuals spit up blood when I attempted forced regurgitation. Two others became so sluggish afterwards that I thought they had been injured. One snake had a bullhead spine puncture its skin when I reached in back of the obvious lump to force regurgitation. This snake then took six hours to regurgitate the bullhead. I also spent many minutes one day trying to force a fat snake to regurgitate the lump I could feel within her. Upon dissection, the lump proved to be seven unborn young. After these experiences only obvious meals were forced from snakes. Thus, small food items may have been missed, if there were any. I rather doubt that there were.

Of the 25 meals identified from snake stomachs or from observations of snakes actually swallowing prey, 15 were tadpoles (Rana catesbeiana), 4 Brown Bullheads (Ictalurus nebulosus), 3 other fish and 3 other birds (Cliff Swallows). Only one snake had eaten more than one prey item. This snake was observed eating three tadpoles in rapid succession (this was counted as one tadpole meal).

These snakes will eat dead prey including tadpoles, fish, and possibly birds. Snakes were observed eating dead tadpoles and fish that had been stranded as the water receded, or thrown to shore by researchers.

The scarcity of fish in the diet of these garter snakes may be due to the difficulty in capturing them. Green Sunfish (Lepomis cyanellus), Carp (Cyprinus carpio), and Golden Shiner (Notemigonus crysoleucas), were trapped at 1W and 2W, so they were potentially available to the snakes. However, even in the lab under excellent conditions for the snake, sunfish and shiner are almost impossible to catch. Two snakes were seen this summer scavenging dead fish, probably carp. Another was seen with an unidentified wiggling fish tail sticking out of its mouth.

The Brown Bullheads eaten by snakes were probably taken alive. They were at least 10 times as concentrated as tadpoles in the water under 1W, and at least 20 times as concentrated as tads at 2W. Apparently the snakes can catch tadpoles much easier than Brown Bullheads. Of the four snakes known to have eaten bullheads in the field, two had problems with protruding spines. One was mentioned earlier in this section. The other was found with a spine protruding through its ventral surface. This snake was taken to the lab for observation. After several weeks of being offered no food, it was allowed to eat two tadpoles. It regurgitated the tadpoles after several hours, but the spine of the fish was pushed inside and down to the snake's stomach. This animal was alive and well five months later.

All three birds eaten were swallows. Cliff Swallows nested under the steel bridge and the little bridges, and were the most common small bird at the SSS. One swallow was an unfledged young with flight feathers still ensheathed. Another was apparently an adult. The third regurgitated bird was actually only a swallow's head. It is not known what happened to the rest of the bird. Carpenter believed that birds were dead when taken by garter snakes in Michigan. This was probably true of mine. I do not see how a snake could have climbed to a Cliff Swallow's nest, five feet above the water on the underside of the small

bridges, as there seemed to be nothing to climb up. Swallow eggs were found once in the water under a bridge. It is conceivable that a young bird could have fallen out of a nest before being eaten. Another time I found a stunned adult swallow that had apparently flown into a rock wall. A snake might have run across such a bird on occasion.

Tadpoles were the most common food of snakes this summer. This is consistent with most of the literature, which suggests that amphibians or earthworms are the most important source of food for this species depending on location (Uhler et al, 1939; Fitch, 1941; Lagler and Salyer, 1945; Breckenridge, 1944; Barbour, 1950; Hamilton, 1951; Carpenter, 1952; Fitch, 1965).

Hunting Behavior

Snakes were observed hunting on a few occasions. Three or four basic strategies, with variations in execution, were used for finding and catching food.

One strategy involved rousting out motionless prey. There were two variations on this strategy. Two snakes, seen at different times, made short, quick swimming movements on the surface, alternating with motionless watching. Another snake was seen thrusting its head into mud under very shallow water. Then it moved its head around in circular motions before pulling it up and pushing it back into the mud a few centimeters away. Both of these behaviors seemed to force motionless aquatic vertebrates to move. The snakes seemed to see the movement and grab at it. They did not recognize motionless frogs or tadpoles.

Some snakes responded to movement without having elicited it. Many snakes were seen quietly lying on the surface of the water. The reason that I believe they were hunting when they did this is because they responded immediately to any movement. Such movement might have been a frog swimming, a tadpole surfacing for air, or even the splash of a rock thrown into the water. The response was either an immediate lunge in the direction of the movement, or a new, more alert attitude which included raising the head, looking around, and flicking the tongue. Other snakes seen lying motionless on the water were observed a short time later with big bulges in their bodies, indicating a successful hunt.

Two very frustrated snakes were seen lunging repeatedly toward splashing frogs. If the concentration of frogs was high, a chain reaction began, because when a snake lunged at one frog, more frogs jumped. One snake was observed, by another member of our group, lunging at an adult Bullfrog much bigger than itself. This snake grabbed the frog's foot, probably in response to movement, but let go when it could not swallow the frog.

In the lab, snakes nosed around under water, frequently with mouths open, randomly running into prey and grabbing them. Such behavior was observed once in the field. It was a very successful method in the shallow water at 2.5E where one snake caught and swallowed three tadpoles in less than five minutes. I think that this random, open-mouthed underwater hunting is fairly common. Even a tiny snake, born this summer, employed this method in the lab, apparently instinctively. A few snakes were seen in the field diving from the surface into water three or more feet deep, and two were caught in minnow traps in three feet of water. I think that these snakes were able to catch tadpoles and catfish underwater, in ponds as they do in the lab.

Three snakes were observed hunting out of the water, nosing around in depressions in dry mud from which the water had receded. Dead fish and tadpoles were found in such places. However, dead prey were not taken indiscriminately.

I watched one snake touch several fish with its snout and tongue before choosing one to swallow. Then it inspected other dead fish before moving off to bask.

Carpenter (1952) thought that tongue-flicking was important in one garter snake's search for food. This snake did not seem to be able to see frogs that were two or three feet away, and did not "smell" them until within 8-10 inches. I did observe tongue-flicking in hunting snakes, especially those on land and those resting on the water's surface who had just seen movement. However, I think that visual cues, involving movement, and random underwater hunting were more important for this particular population of snakes in successful hunting. However, those eating dead prey probably do depend more on chemoreception.

A few snakes in the field, and most in the lab, carried captured prey out of the water before swallowing it. Then when a snake dropped its prey on land, as frequently happened in the lab, it could usually grab the prey again before it flipped into the water. Both catfish and tadpoles survived at least tens of minutes out of water at about 20C in the lab.

The 15 or so observations of snakes hunting occurred between 1000 and 1500 hours.

Daily Activity Pattern

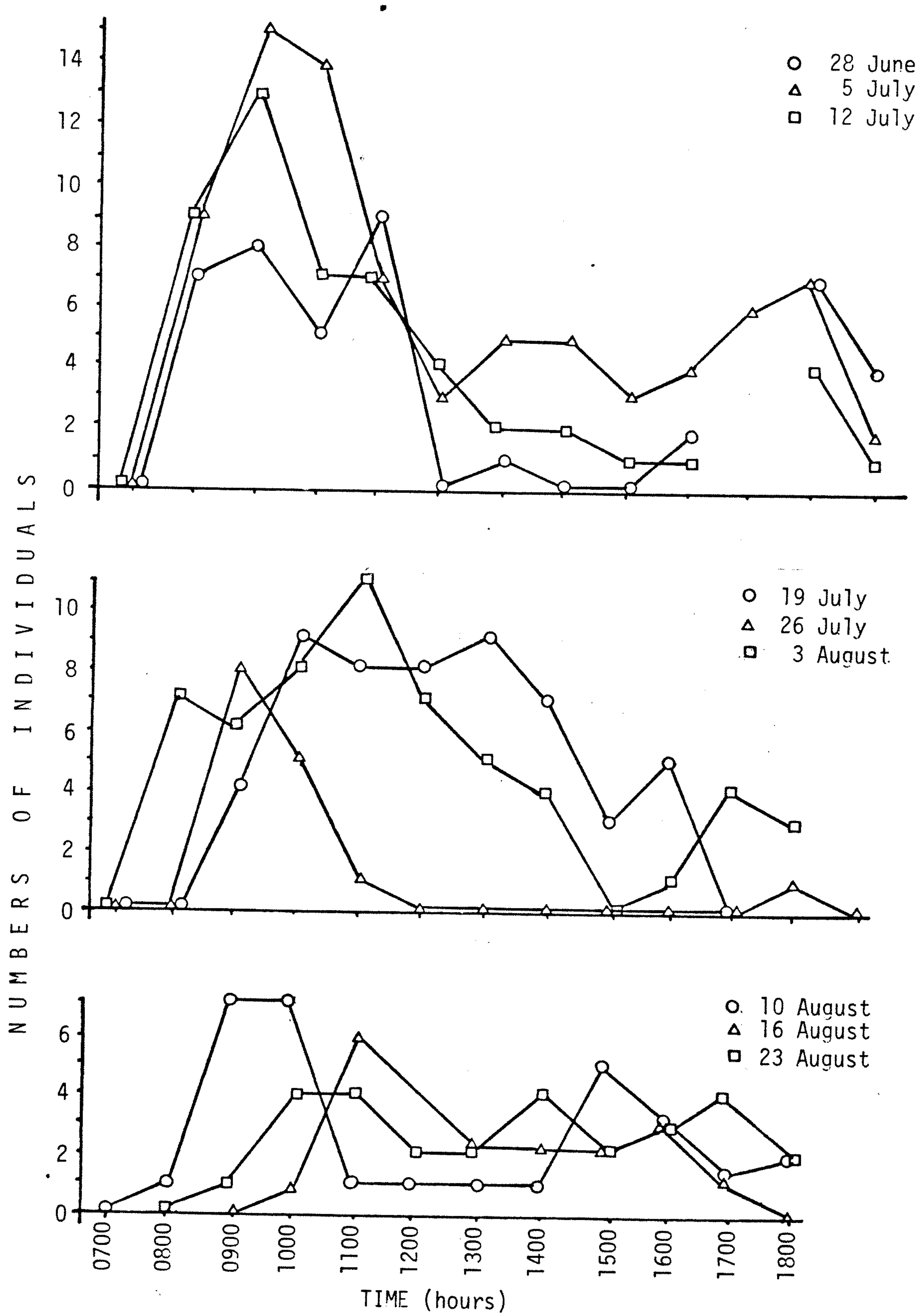
Snake activity was measured by counting snakes along the SSS hourly, from 0700 to 1900 hours, once weekly. The data were analyzed using Random Block Design Analysis of Variance (RBDAV), hour of the day vs. date. Because some of the 1700 and 1900 hours' counts were not taken, they were left out of the quantitative analysis. It was determined that significantly more snakes were seen at 0900, 1000 and 1100 hours than at any other times of the day (Figure 6.03 and Table 6.08).

The snakes came out to bask in the early morning sunshine; most of them emerging between 0700 and 0900 hours at the beginning of the summer, and between 0800 and 1000 hours at the end of the summer. After spending a short time in direct sunlight, some left the snake walk area or went underground, but most moved into bushes or coiled up in the grass. By 1000 hours most snakes were concealed in more or less shady places and were difficult to find. At midday when the air temperature reached a maximum (30-36C), usually at about 1300 hours, few snakes were out. On the two dates, 3 August and 19 July, when more snakes were out in the middle of the day, relatively cool temperatures were recorded. August third in particular was cool, with a maximum temperature of 22C at 1600 hours; it was also overcast most of that day. On 26 July when almost no snakes were seen after 1000 hours, temperatures were higher than any other day that snake walks were carried out (see "Seasonal Activity" for temperatures on this day). Apparently snakes retreated underground or to the water to stay cool when the temperature soared.

In the late afternoon, when air temperatures dropped, there seemed to be a second peak of activity, less obvious than the morning one (Figure 6.03). At that time, many snakes were found in direct sunlight again. Frequently a snake was seen actually crawling slowly into a ground squirrel burrow, apparently not due to my presence. Some were even observed, with head down a burrow and much of the body sticking out, catching a few more minutes of sunshine before retreating for the night.

As mentioned under "Hunting Behavior", all observations of hunting snakes occurred between 1000 and 1500 hours. Hunting in the cool water may be carried

Fig. 6.03. Numbers of common garter snakes seen on hourly walks, once weekly, along 135 m of Dyson Lane, MHSSA, Sierra Valley, CA, 28 June to 10 August, 1976.



out during the midday heat.

Table 6.08. Daily and seasonal activity of Common Garter Snakes, as measured by the number of snakes counted along 135 m of Dyson Lane, just west of the steel bridge, MHSSA, 28 June through 23 August, 1976.

Time (hours)	June 28	July 5	July 12	July 19	July 26	Aug. 3	Aug. 10	Aug. 16	Aug. 23	$\bar{X}$
0700	0	0	0	0	0	0	0	0	0	0.0
0800	7	8	9	7	0	0	1	0	0	3.5
0900	8	15	13	6	8	4	7	0	1	6.9
1000	5	14	7	8	5	9	7	1	4	6.7
1100	9	7	7	11	1	8	1	6	4	6.0
1200	0	3	4	7	0	8	1	4	2	3.2
1300	1	5	2	5	0	9	1	2	2	3.0
1400	0	5	2	4	0	7	1	2	4	2.8
1500	0	3	1	0	0	3	5	2	2	1.8
1600	2	4	1	1	0	5	3	3	3	2.4
1700	-	6	-	4	-	0	1	1	4	2.7
1800	7	7	4	3	1	0	2	0	2	2.9
1900	4	2	1	-	0	-	-	-	-	2.3
$\bar{X}$	3.5	6.5	4.5	4.7	1.4	4.8	2.6	1.8	2.2	

Seasonal Activity

Snakes were found in large numbers from 8 June through 28 August and 11 through 13 September. A few were found on 9 and 10 October. Almost none could be found in many hours of searching on 29 through 31 October and none were found in the MHSSA on 20 and 21 November. A few snakes were seen prior to 8 June before I found them concentrated in the SSS. I do not know how much earlier they emerged from hibernation.

Three methods of measuring the seasonal activity of snakes were used from 28 June through 28 August. None indicated any pattern of change in the abundance of snakes over this two month period. The two mark-and-recapture methods will be discussed under "Density". Snake walks carried out once weekly were analyzed using RBDAV, hour of day vs. date (data from 1700 and 1900 hours were not used as they were not complete for each week). Significantly more snakes were seen on 5 July than on 26 July and 10, 16 and 23 August. The apparent decrease in activity was probably related to the destruction of cover along the road. Bushes, grasses and forbs were heavily grazed by cattle; by late August, little shaded area was left, and I think that the snakes sought shade underground and in the rock wall where they were not visible from the road. Each individual might have spent just as much time basking in the open as before, but once shade was chosen, I could not see them as I could when they sought shade under the bushes.

Air and surface temperatures seemed to correlate with the snakes' activity on different days. On the hottest day that snake walks were carried out, 26 July, snakes were seen only at 0900 and 1000 hours (with one snake seen at 1100 and 1800). At these times the air and surface temperatures were between 20 C and 30 C, the normal body temperature range of active snakes (Carpenter, 1956). By noon the air temperature was 34.5 C and the substrate temperature 36 C. A snake in sunshine at this temperature would reach its lethal limit, 41 C (Leuth, 1941) within minutes, and would have great difficulty cooling down even in the shade because of the high air temperatures.

The following week, on 3 August, many snakes were seen in the middle of the day. But midday temperatures were only 21 - 23 C. The snakes should have had an easy time keeping their temperatures low enough, by moving into shade if their black bodies absorbed too much heat. This particular day was quite overcast however, and the snakes stayed out in the open, apparently trying to catch any rays of sunshine possible.

Air and surface temperatures cannot be used to explain all of the fluctuations in snake activity, but they certainly correlate well with it. Snakes cannot operate well when the temperature is too cold or too hot. In late October, one snake froze at the edge of a pool of water presumably after becoming too cold to move away.

Density

Single and multiple mark-and-recapture estimates of population size were calculated weekly (Table 6.09) as described by Cox (1976). Ninety-five percent confidence limits of single mark-and-recapture estimates are too wide to discern any change in the number of snakes active each week. I know of no way to calculate confidence limits for multiple mark-and-recapture population estimates. These estimates depend on the information compiled in the previous weeks' data however, and should be somewhat better estimates than those from a single mark-and-recapture. Notably, the last three multiple mark-and-recapture estimates are essentially the same, so perhaps there were about 35 snakes active during those weeks.

I think that two assumptions of mark-and-recapture estimates were not satisfied in this study. Immigration probably occurred in the second half of the summer. As water dried up in the roadside ditches along Dyson Lane, snakes may have wandered around looking for better fishing holes. Fish and tadpoles were easier to dipnet at 1W and 2W than at 3W, 4W, 5W and 6W in August (Figure 6.01). Therefore fishing was probably better in and immediately next to the SSS than west of it. Many snakes may have moved into the area after finding the fishing good. Because there was up to two weeks between marking and recapturing (Day 1, Week 1 to Day 7, Week 2), for each weekly population estimate, an influx of new snakes may have had a large effect on the estimate. It would tend to make the estimate too high.

I may not have sampled the entire SSS adequately, thus not satisfying another assumption of the mark-and-recapture procedure. Since many individual snakes seemed to use a favorite place for basking and retreating from the sun, I may not have sampled individuals that basked below the road bed. I did not realize that there were many such snakes until mid-August, so I missed all of them in my estimates.

In addition to the two problems just mentioned, the SSS does not include

the entire home range of all snakes caught there. Many snakes caught east of 2W (on the SSS) were also caught west of 2W (just off the SSS) at different times of the summer.

Table 6.09. Weekly population estimates of Common Garter Snakes along the 135 m of Dyson Lane immediately west of the steel bridge, MHSSA, 28 June through 22 August, 1976.

Week of:	Single Mark-and-recapture				Multiple Mark-and-recapture		
	No. Marked	No. Recaptured / No. in Sample	Pop. Est.	95% CL	No. Marked	No. Recaptured / No. in Sample	Pop. Est.
28 June	13	6/12	26	17-59	13	6/12	—
5 July	5	4/16	20	11-125	16	5/15	—
12 July	12	6/17	34	21-92	21	5/13	—
19 July	7	1/3	21	12-88	26	1/2	54
26 July	2	2/26	26	11-	27	14/20	78
2 August	20	2/10	100	44-	41	6/9	34
9 August	8	2/14	56	25-	47	4/10	36
16 August	9	3/14	42	21-	51	1/10	35

Seibert (1950) experienced problems with the mark-and-recapture of *Thamnophis radix* and other snakes near Chicago. His recoveries of marked snakes did not consistently increase as he marked more and more of the population. I had the same problem, but perhaps in my case, it can be explained by an influx of new individuals into the population.

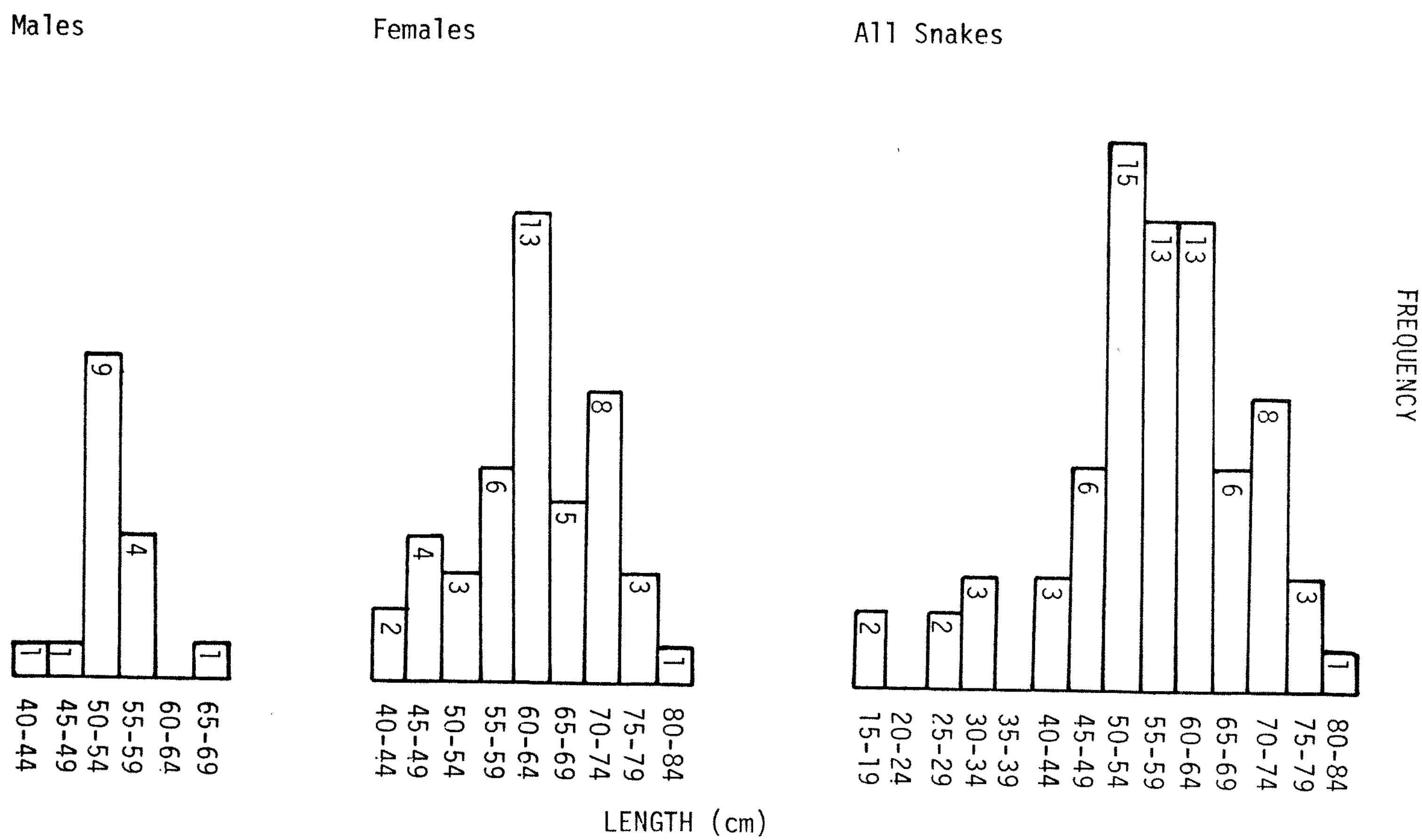
Fifty-nine different snakes were caught on the SSS over the summer. Deaths were recorded for six of these. I do not think that all of these snakes were actually present on the study site all summer. Certainly they were not all active above ground for that entire time. Most snakes seen early in the summer were not seen late in the summer. Perhaps predation was very heavy. The snakes and the birds that feed on snakes were concentrated in areas where water remained.

In conclusion, no change in seasonal abundance from 28 June through 22 August was found, although by late October there seemed to be a decided decrease in activity. By mid-November no snakes could be found although a few may have been active. No good estimate of population size could be determined because assumptions of mark-and-recapture estimates were not met; but 59 different individuals were caught and the minimum population size during July and August was approximately 20. In August, the population size seemed to be about 35.

Growth and Reproduction

Snout-vent lengths of all snakes measured this summer ranged from 17 to 84 cm; total lengths ranged from 25 to 96 cm. Females were longer than males in snout-vent length. The average female was in the 60-64 cm class and the average male in the 50-54 cm class (Figure 6.04). Carpenter (1952) and Fitch (1965) also found about a 10 cm difference in the lengths of females and males

Fig. 6.04. Frequencies of snout-vent lengths (cm) of male, female and all common garter snakes measured in MHSSA, Sierra Valley, CA, June through September, 1976.



of this species in Michigan and Kansas, respectively. Carpenter's snakes were much shorter than the ones in the MHSSA. Fitch's were similar in size to mine although his snakes showed a greater range in size. Individuals 17-32 cm or shorter were believed to be the young of the year, although some of the larger ones may have been small one year-olds. Fitch (1965) found that newborn T. sirtalis in Kansas ranged in size from 13 to 19 cm. After three months of growth, these young snakes averaged 27.6 cm.

Apparently female snakes grow faster than males. Fitch (1965) found an apparent difference in size and growth rate of first year snakes and an obvious difference in older snakes. Adult snakes grow very slowly and erratically. The larger size of females is probably advantageous in this live-bearing species in which the upper limit of clutch size might be determined by the room available for housing young.

Young snakes were probably born in late July this year. In June and July any "big" snakes seen by members of our research group were females. Such big individuals were not much longer than the "small" snakes seen, but they were obviously thicker. In August no one reported seeing big snakes. In fact, I was asked what had happened to them. Individual snakes that had looked big to me, in June and July, suddenly looked smaller.

Table 6.10. Numbers of individual female and male Common Garter Snakes seen in the MHSSA, from 28 June through 28 August and 11 through 13 September, 1976.

Week of:	Numbers of Different Individuals		$\frac{\text{Females}}{\text{Males}}$
	Females	Males	
28 June	12	3	4.0
5 July	11	3	3.7
12 July	14	6	2.3
19 July	10	6	1.7
26 July	10	3	3.3
3 August	17	3	5.7
10 August	10	5	2.0
16 August	11	2	5.5
23 August	11	3	3.7
11 September	14	8	1.8
Totals	45	16	2.8
Averages ($\overline{X}$)	12.0	4.2	2.9

A female snake collected dead on 15 July had four big (1X3 cm) eggs inside with a tiny snake on the surface of each. The following day, two dead females were collected. One had no eggs or young inside; the other had seven well-developed babies, 15-16 cm in snout-vent length. They looked as if they were ready to be born. A gravid female was found killed by a bird on 20 July. Immediate dissection revealed 21 young, apparently ready to be born.

On 26 and 28 July, two members of our research group saw one tiny snake. On August 4, 6, 10 and 27, I caught small snakes, 19-32 cm in snout-vent length. These small snakes look somewhat different than the adults. They have very yellow venters, instead of the bluish-gray or white venters of the adults. The upper labials of the small snakes are almost square instead of being higher than wide.

Carpenter (1952) found young snakes of this species in Michigan, from late July through September. Fitch (1965) reported that T. sirtalis in Michigan are born in the last week in July through the second week in August.

Carpenter (1952) reported that 16% of all females or 65% of adult females of this species were gravid each year. He suggests that this might be because not all females come in contact with males.

Snakes were so dense in the SSS that four or more were frequently seen within a meter of each other when basking. Two or more snakes, of the same or different sexes, were frequently seen coiled up together. The snakes do find each other easily. Of the four female snakes inspected for young, the three with young were collected on the SSS. The other was collected nearby where the population is not so dense. I feel that it is quite possible that all mature females on the SSS were gravid; at least most were.

Eighteen young was determined to be the average brood size for 20 females of this species in Michigan (Carpenter, 1952). Twelve to 24 is average for the species as a whole, depending on geographic location (Stebbins, 1963). The average brood size for the three gravid females found this summer was 12. There was a big variance in this sample of brood sizes however, as 4, 7 and 21 young were recorded. Therefore, this average is not too dependable.

Breeding in this population may occur in late summer or early fall. A male and female collected live on 27 August, demonstrated mating behavior in the lab a few days later, continuing for at least a week. These two individuals were collected simultaneously in the field as they lay stretched out next to each other under a bush. They may have been copulating then. Fitch (1965) says that mating occurs in the spring, so perhaps MHSSA snakes breed then also.

Mortality

Eighteen dead snakes were found last summer. Of these, eight snakes had large wounds, eight had been run over or hit by cars and two were found dead in minnow traps.

The snakes found with big wounds were all but severed into two or three pieces. It is believed that these wounds were the result of encounters with large predatory birds. One day I watched a bittern hunting in a small pond. It grabbed at anything that moved. All snakes found with large wounds were big females. They may have been too big for a bird to swallow, or they may have thrashed around enough to escape once caught. However, if a bird grabbed a snake, severe wounds might have been inflicted before the bird gave up or the snake got away. One pregnant female, that I was well acquainted with, was found dead 30 feet from 1W; it had been bitten in two places. The 21 young snakes inside were mutilated; few of them were still in one piece. Three of the other wounded snakes were found dead in water. One had its tail down a hole in the bank. Even in death, its hold inside that hole was too great for me to pull it out. All of the snakes killed by predators were found near, if not in, water. Many others, especially smaller ones may have been eaten.

Thirteen of the 75 snakes caught live this summer had huge dorsal scars similar to the mortal wounds of other snakes, indicating that some snakes do survive capture by bird predators. Many others are probably eaten.

Many, perhaps 50%, of the 75 snakes caught this summer did not have their whole tails, and three individuals had almost none. One snake wound itself up in a bush and pulled so hard, while I held its tail, that a portion of the tail came free in my hand. Another twisted around doing lateral somersaults as my foot rested on its tail until a portion of its tail twisted right off. The large number of snakes without whole tails indicated heavy predation pressure. Whether bird or mammal predators are responsible for the lack of whole tails, I do not know. A coyote found in the valley, north of the MHSSA, had two garter snakes in its stomach. Since coyotes were seen frequently in MHSSA, perhaps they take a significant number of snakes.

Carpenter (1952) mentions that large Green Frogs and Leopard Frogs were observed eating small snakes in Michigan. Bullfrogs may eat small garter snakes in the MHSSA.

I had expected to find many dead snakes on the road this summer. I consider eight snakes to be quite a small number killed by cars along a 2.5 mile stretch of dirt road in 12 weeks. Although the snake population is very dense along the road, the snakes bask at the edges of the road, which are not used much by cars. They rarely cross the road. Any individual seen on one side of the road usually stayed there for days or weeks.

SUMMARY

Rana catesbeiana, the Bullfrog, was the only species of amphibian found in the MHSSA during the summer of 1976. The adult population was low and apparently not in good reproductive condition. However tadpoles were numerous; most tadpoles that had overwintered were 8-11 cm long in June. Some metamorphosed in mid-July; while newly hatched tadpoles (2-3 cm in length) were found in mid-August. Tadpoles suffered heavy mortality from dessication in drying pools, as well as from predation by garter snakes and birds.

The Common Garter Snake, Thamnophis sirtalis, was the only reptile in the marsh area. Habitats for this snake included waterways for feeding, with bushes, rockwalls and ground squirrel burrows providing cover. Food consisted mainly of tadpoles with fish, birds and carrion also included in the diet. There was no change in the abundance of snakes from June through August (about 35 snakes were active at any one time), but few snakes were active in October and none in November. Females were about three times more numerous than males. The mortality of these snakes could be attributed primarily to large birds, cars and possibly coyotes.

CHAPTER 7
BIRDS

INTRODUCTION

Marsh lands and other wetlands are important to many bird populations. In fact, many marsh birds show exclusive adherence to this habitat, although some species migrate between fresh and salt water marshes. The scattered marshes in arid, northeastern California are especially important nesting sites for birds. Several nesting studies have been done in this region, at places such as Honey Lake (Hunt, 1955) and Eagle Lake (Leherer, 1976). Large numbers of waterfowl, as well as many other water-associated birds, nest and migrate through this region. Chapters of the Audubon Society and many other students of nature frequent Sierra Valley because of the rich avian fauna.

Although Sierra Valley lies within the Sierra Nevada Geomorphic Province and Honey Lake does not, both areas are dominated by vegetation typical of the Great Basin (e.g. sagebrush). In fact, Sierra Valley is listed within the Basin and Ranges Province by Small (1974). Therefore, it is reasonable to assume that the variety of birds reported for nearby Honey Lake and vicinity also occur in Sierra Valley, and, indeed, this assumption is supported by observations of the Golden Gate Audubon Society (MacCaskie and Benedictis, 1966).

Two observers surveyed the bird populations of the MHSSA during a 12-week period from June through August, with additional observations in April, May and September, 1976 and April, 1977.

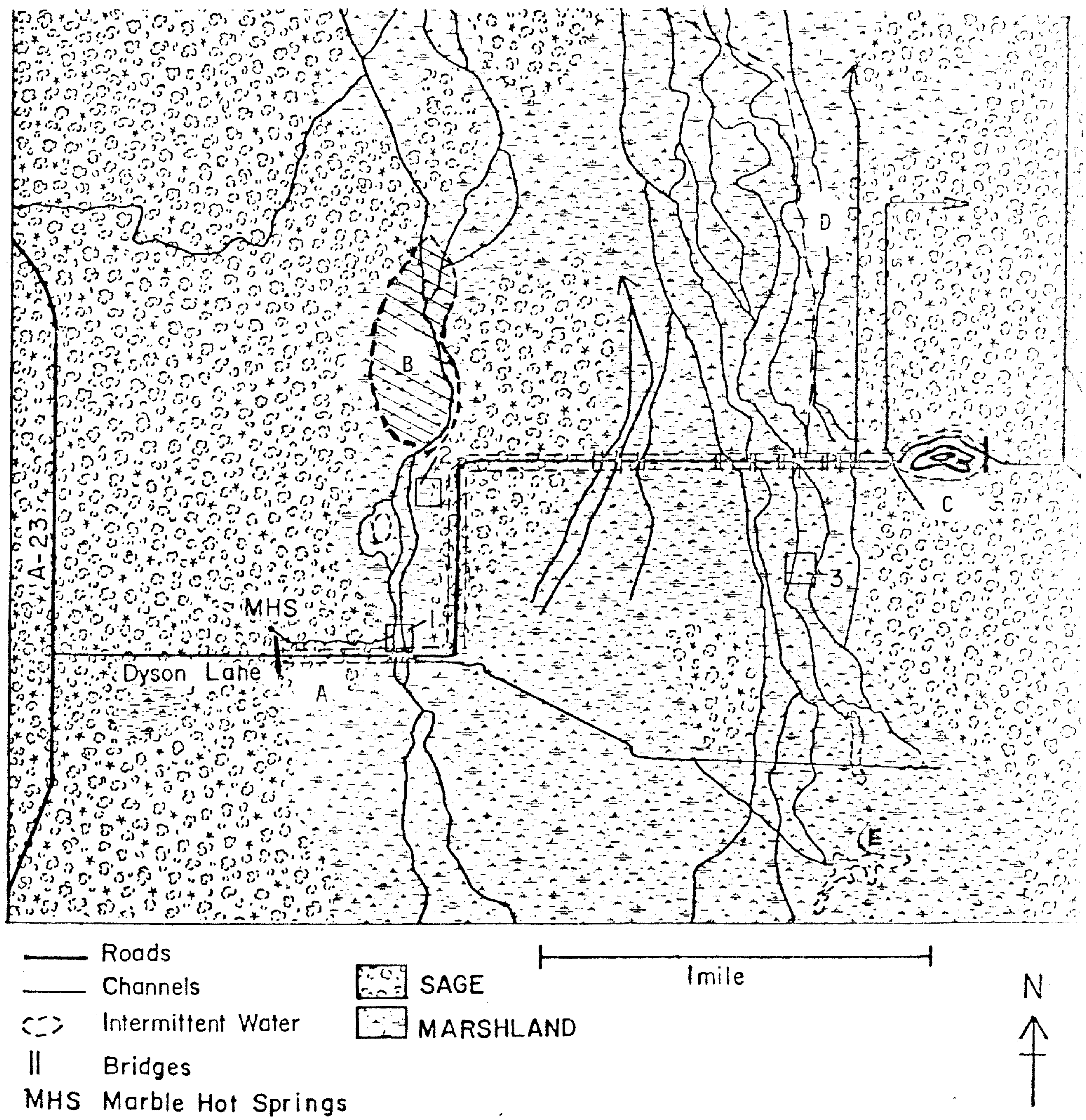
METHODS

A bird survey was carried out for 12 weeks, beginning June 12, 1976. The survey included two bird-count areas and nest counts in the three study sites, as well as random observations made in adjacent areas.

The first count area was along Dyson Lane: proceeding east from the Hot Springs for 2.35 miles, ending near the intersection of Rte. A24 (Figure 7.01). The species and number of individuals encountered were recorded. Counts were made twice weekly and started at 6:00 a.m. and 6:00 p.m., since these times are apt to give the largest number of birds (Grinnell and Miller, 1944). No attempt was made to flush birds along the road during the count. The road was walked at a constant slow pace and the observer used binoculars to identify the species. Dyson Lane is bordered on both sides by irrigation ditches, runs through areas of sagebrush and wetlands, and crosses three major channels (Figure 7.01). This route was chosen because of its accessibility and diversity of habitat; it can be run at any time without crossing fences or entering private property.

Another area (B) was walked by one observer in a similar fashion. However, this count covered 80 acres (32 hectares) of mixed sedges and rushes with large expanses of water, two to four feet deep. Area B is the northern extension of two channels running north from Study Site 1 (Figure 7.01). It was chosen for its large, relatively uniform habitat, as well as the many birds nesting, feeding and seeking cover there. Area B is bordered by sagebrush and alkali flats, and seems typical of the Sierra Valley marshes. This area was walked once a week at 6:00 a.m. for seven weeks, at the end of which the water had completely dried up. The average number of each species for the 80-acre area was extrapolated to an estimated average density for 100 acres. A relative abundance was calculated for each species using the average number of individuals in a species divided by the

Fig. 7.01. Map of bird count routes, MHSSA, Sierra Valley, CA, 1976. A - Dyson Lane road count, B - Area B, C - Duck Pond, D - Sierra Valley channels (north), E - extensive deep water marsh.



average total number of individuals, as is suggested by Oelke (1969). A plot census of nests was taken within each of the three study sites. The nest sites were located by having two persons, five meters apart, walk parallel transects the length of the site (100 m). When a nest was located it was recorded on a vegetation map along with a nest and egg description, date and plant associates, which were recorded on separate sheets. In order to locate nests a second time a piece of blue plastic flagging (such as that used by survey crews) was tied onto a piece of vegetation close to the nest. However, all tagging disappeared before the nests were checked a second time. Although our attempt to monitor nests failed we were able to correlate vegetation preferences with the species of bird.

Observations were made in surrounding areas in order to find nests (establishing the breeding status of that species) and record uncommon species possibly missed during bird counts. Night observations were undertaken for nocturnal birds as well as to observe any nocturnal activities or movements from one area of the Valley to another. Further observations were carried out in two-day periods in mid-April, May and September, 1976 and in the spring of 1977. All of the observations contributed to an annotated species list.

RESULTS

Bird Counts

The bird counts taken along Dyson Lane yielded population data for this area of the MHSSA. Fifty-three species were monitored through these counts (June 28 - August 19, 1976). Of these 53 species, 23 were common (i.e. seen daily) throughout the study. Table 7.01 is a listing of these 53 species with the common species indicated with an asterisk. The relative abundance is also given for 32 species; these figures are for mid-July (July 10-12), a time during the breeding season when the majority of species were most abundant.

Of the 53 species monitored through the road counts, 12 were present in large enough numbers to warrant graphing their population fluctuations (Figures 7.02, 7.03 and 7.04). Figure 7.02A shows an apparent difference in the times of peak populations of two dabbling ducks (Cinnamon Teal and Pintail). Figure 7.03B indicates that our study began too late in the season to observe the initial increase in numbers of the more common shorebirds (e.g. Wilson's Snipe, Killdeer). All of these figures show an abrupt drop in the densities of several, dissimilar birds (ducks, shorebirds, swallows and blackbirds) in late July, when the marsh had largely dried up.

An additional count was also taken in Area B (Figure 7.01) and the results of this count are shown in Table 7.02. This section of marsh is a prime habitat, as indicated by the large numbers of the four, most abundant species: Wilson's Phalarope, Black Tern, Cinnamon Teal and Yellow-headed Blackbird.

Nesting

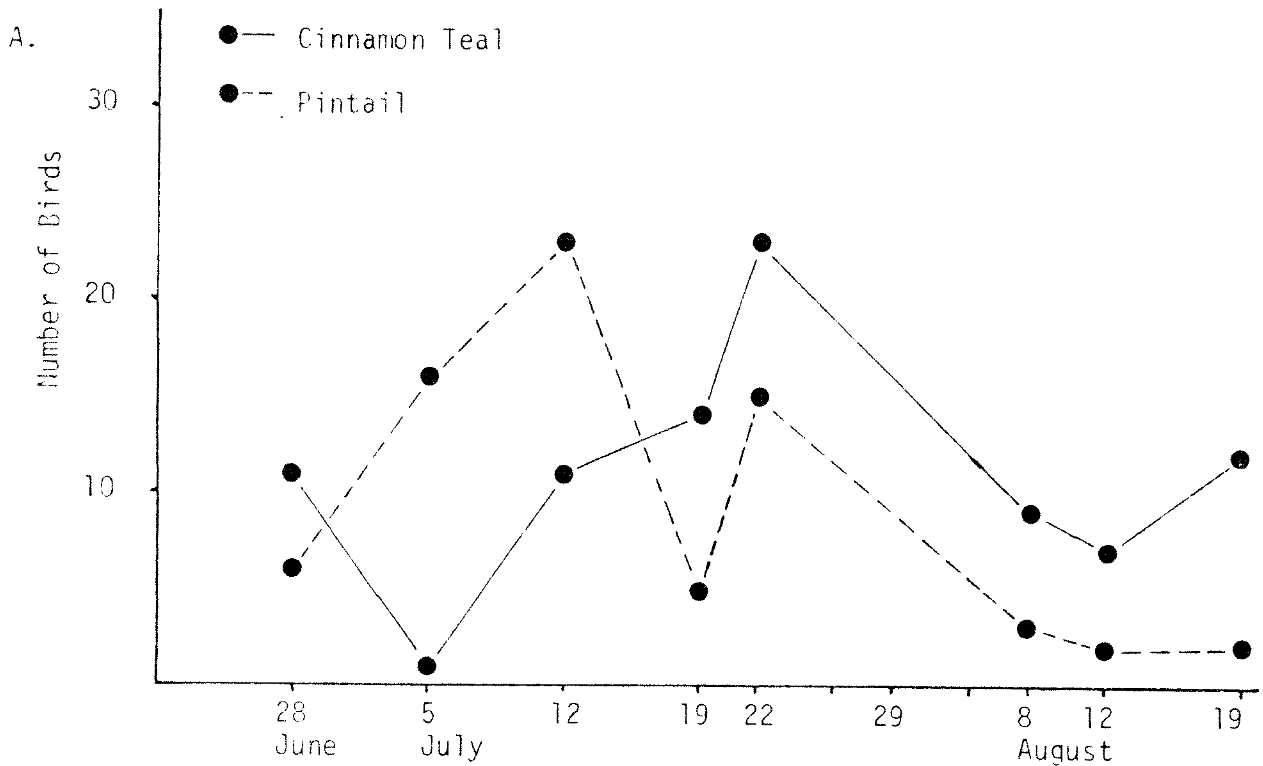
We found 31 species breeding and 9 others which probably bred in the MHSSA. The status of the 53 species monitored through counts is shown in Table 7.01.

The nests found within each study site are indicated in Table 7.03. The density of nests in the study sites was not calculated because we felt that each study site was too small and the number of nests per species insignificant. The nesting success was also not calculated, due to inadequate data. However, five broods of Redheads were reared in "duck pond"—an area outside of Study Site 3

Table 7.01. List of bird species monitored through counts in the MHSSA (June through August, 1976); taken along Dyson Lane and in Area B. Common species are indicated by an asterisk (*). Relative abundance figures are for mid-July (July 10-12). Seasonal status is indicated by B, breeding; PB, probably breeding; T, transient; U, uncertain status; OVR, other valley residents.

Species	Status	% Rel. Abund.	Species	Status	% Rel. Abund.
Pied-billed Grebe*	B	.96	Least Sandpiper	T	—
Black-crowned Night Heron*	PB	.48	Forster's Tern	U	—
American Bittern*	PB	.21	Black Tern*	B	1.45
Great Blue Heron	T	—	California Gull	T	—
Mallard*	B	2.41	Ring-billed Gull	T	—
Gadwall	B	—	Mourning Dove	OVR	—
Green-winged Teal	U	—	Common Nighthawk	OVR	—
Blue-winged Teal	PB	.96	Horned Lark*	B	1.73
Cinnamon Teal*	B	.96	Violet-green Swallow	OVR	—
Redhead*	B	2.35	Tree Swallow	OVR	—
Pintail*	B	1.7	Barn Swallow*	B	10.4
Ruddy Duck	B	.14	Cliff Swallow*	B	35.6
Shoveller	T	—	Raven	OVR	—
Turkey Vulture	OVR	—	Crow	OVR	—
Marsh Hawk	OVR	—	Black-billed Magpie	OVR	—
Sparrow Hawk*	B	—	Long-billed Marsh Wren*	B	.83
American Coot*	B	3.74	Sage Thrasher*	B	.07
Virginia Rail	B	.07	Starling	OVR	.14
Sora Rail	B	.14	Western Meadowlark*	B	.14
Sandhill Crane	B	.14	Yellow-headed Blackbird*	B	18.0
Killdeer	B	2.35	Red-winged Blackbird*	B	4.0
Wilson's Snipe*	B	.90	Brewer's Blackbird*	B	2.41
Wilson's Phalarope*	B	5.52	Brown-headed Cowbird	B	—
American Avocet	B	—	Savannah Sparrow*	B	1.1
Black-necked Stilt	B	.28	Vesper Sparrow	PB	.14
Willet	B	.69	Brewer's Sparrow	PB	.07
Long-billed Dowitcher	T	—	House Finch	B	—

Fig. 7.02, A-B. Population data from bird counts taken along Dyson Lane (2.35 miles, beginning at Marble Hot Springs), MHSSA, Sierra Valley, CA, 28 June - 19 August, 1976. A: Cinnamon Teal and Pintail. B: Redhead and Coot.



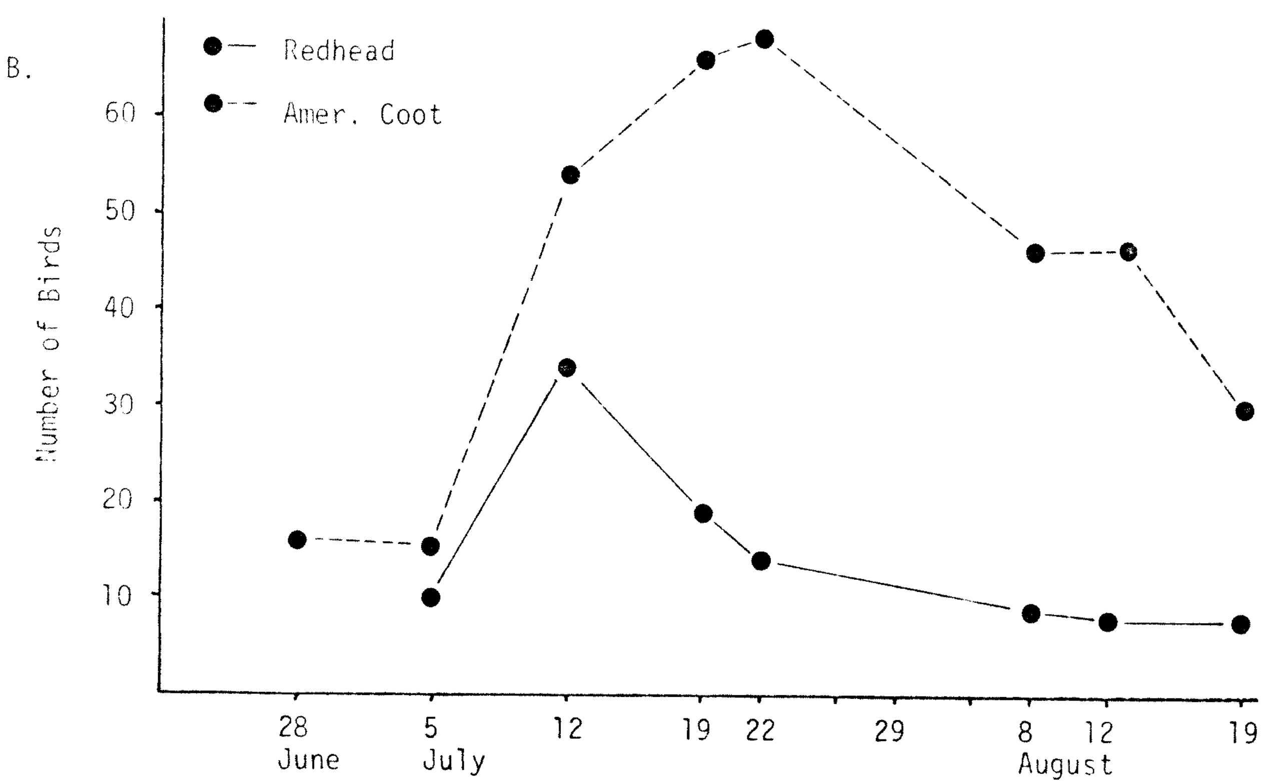
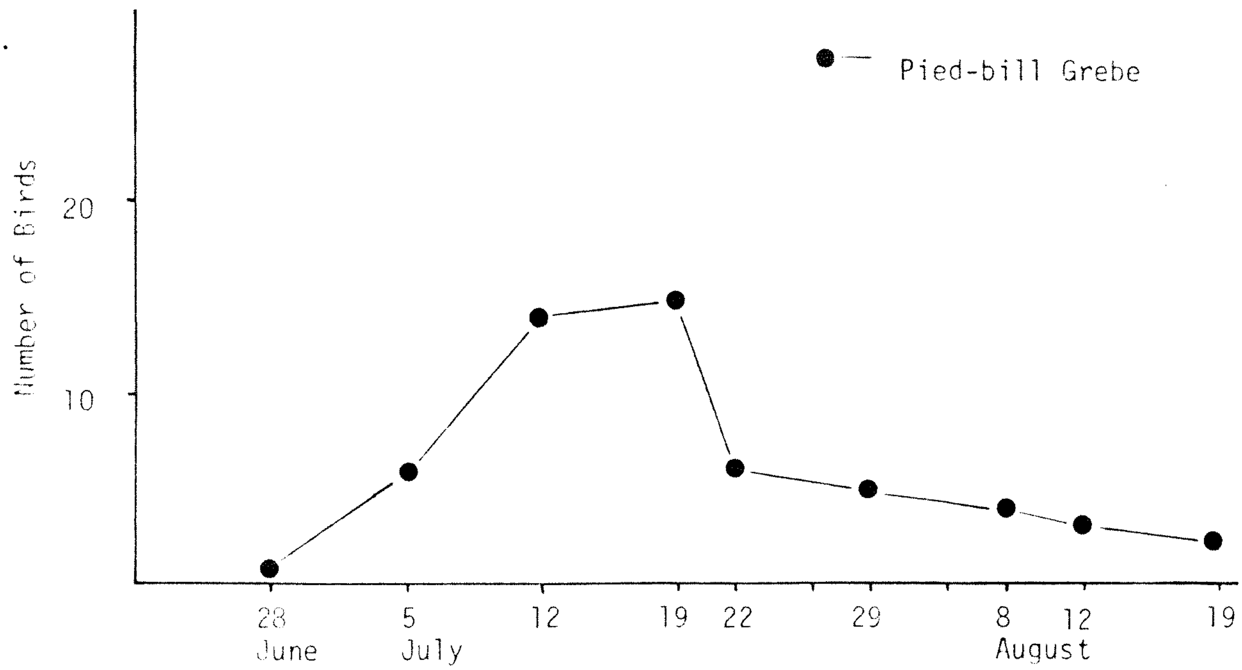


Fig. 7.03, A-B. Population data from bird counts taken along Dyson Lane (2.35 miles, beginning at Marble Hot Springs), MHSSA, Sierra Valley, CA, 28 June - 19 August, 1976. A: Pied-billed Grebe. B: Killdeer and Common Snipe.

A.



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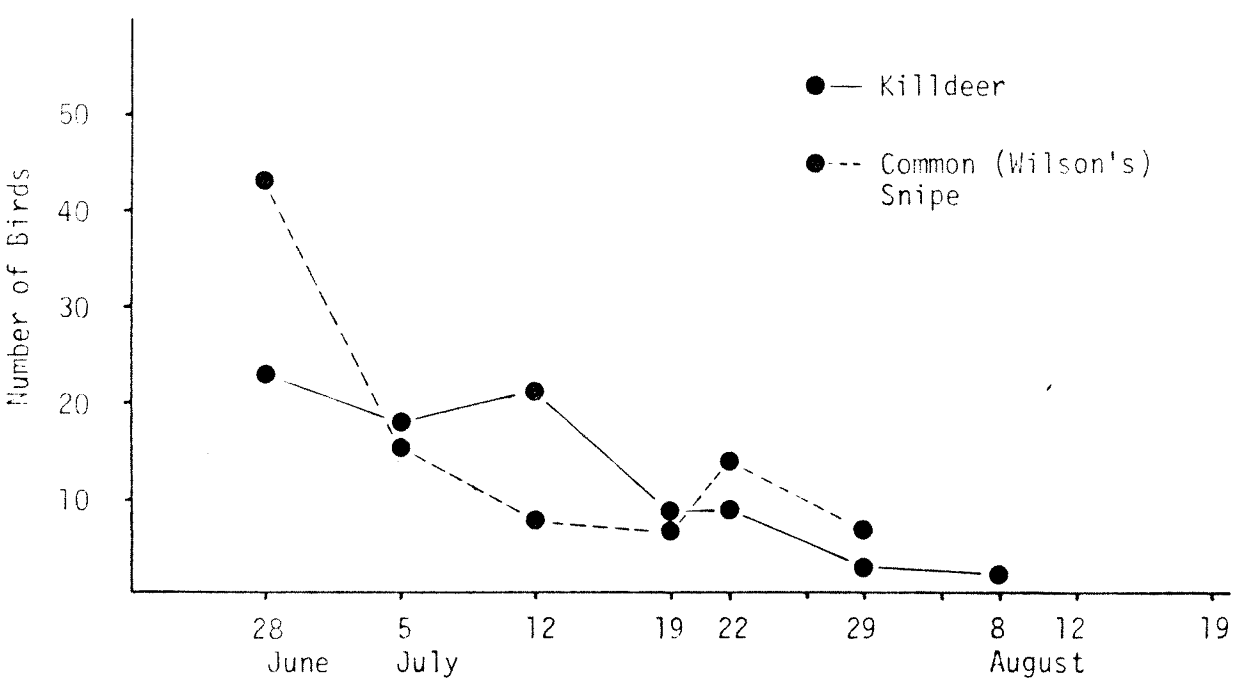
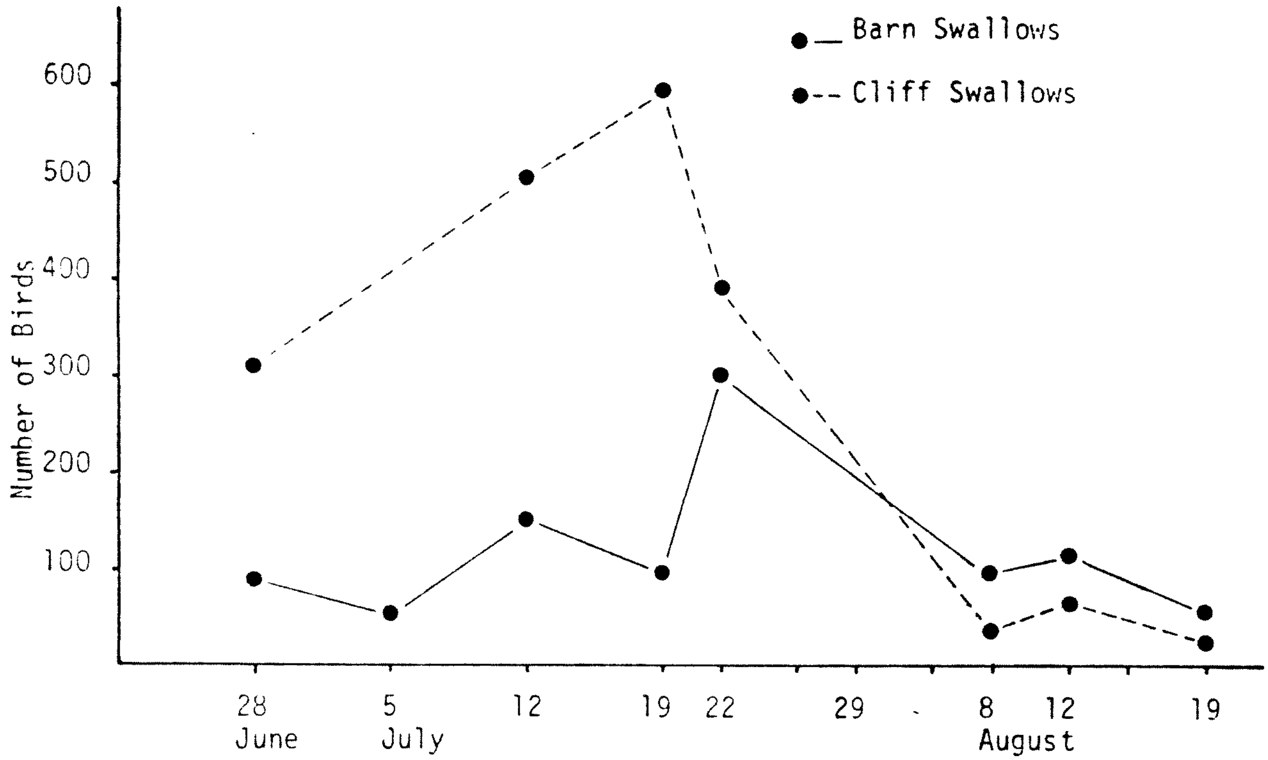


Fig. 7.04, A-B. Population data from counts taken along Dyson Lane (2.35 miles, beginning at Marble Hot Springs), MHSSA, Sierra Valley, CA, 28 July through 19 August, 1976. A: Barn and Cliff Swallows. B: Yellow-headed, Brewer's and Red-winged Blackbirds.

A.



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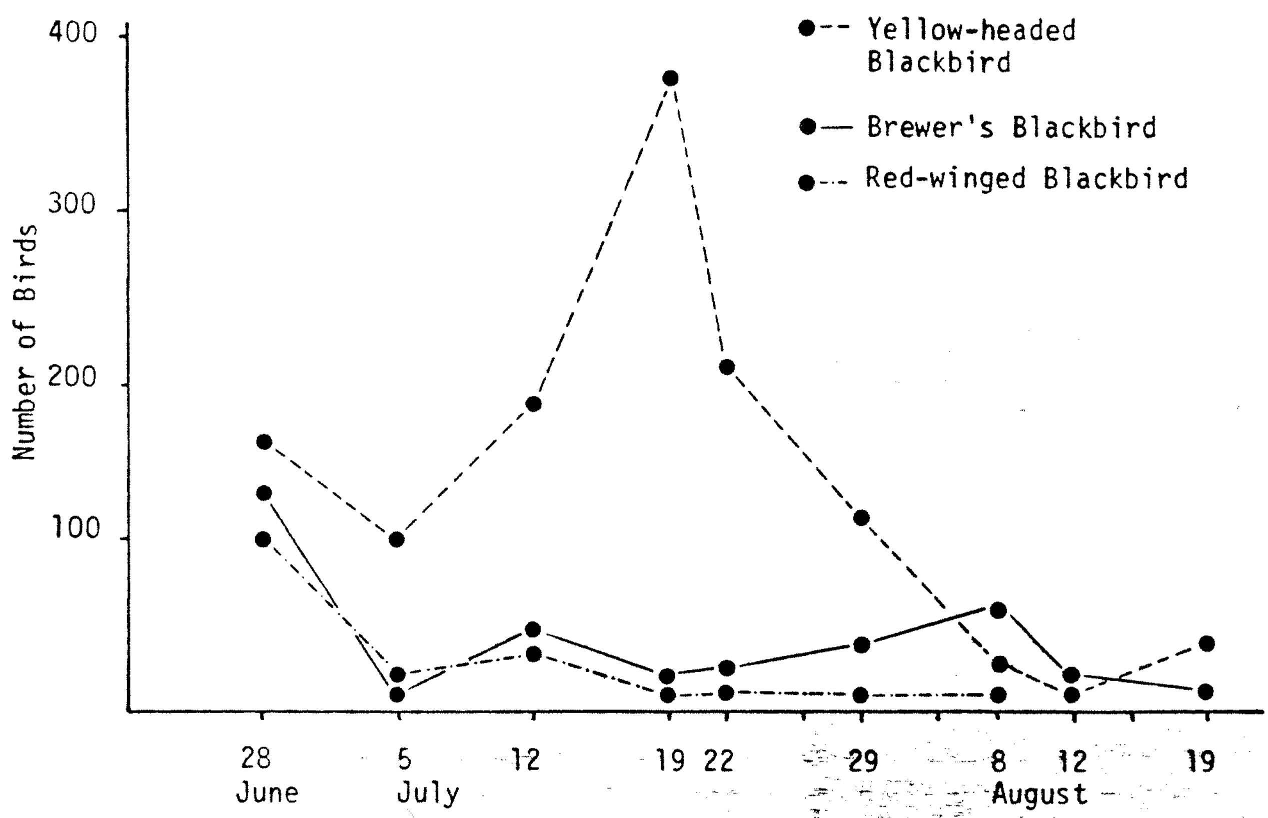


Table 7.02. Data from the Area B bird counts, MHSSA (June 18 through July 29, 1976). (Species listed in order of decreasing abundance.)

Species	June	July						Total	Ave./ Count	Density/ 100 Acres
	18	1	9	10	15	22	29			
Wilson's Phalarope	51	37	51	80	36	16	0	271	38.7	48.4
Black Tern	12	11	(73)	21	29	0	0	166	27.7	34.5
Cinnamon Teal	43	40	3	46	24	2	0	155	25.8	32.3
Yellow-headed Blackbird	—	27	81	7	6	—	24	145	24.2	30.2
Killdeer	32	16	13	26	45	19	5	156	22.3	27.8
Red-winged Blackbird	—	44	27	2	6	7	—	86	14.3	17.9
Mallard	21	11	27	34	5	0	0	96	14.0	17.5
Snipe	17	16	5	30	12	4	0	84	12.0	15.0
Willet	28	3	8	6	19	—	1	64	9.1	11.4
Brewer's Blackbird	0	16	0	0	6	8	0	30	4.3	5.4
Pintail	4	2	2	13	3	0	0	24	3.4	4.3
Black-necked Stilt	3	2	4	0	9	—	—	18	3.6	4.0
Horned Lark	0	0	7	6	0	0	4	17	2.4	3.0
Savannah Sparrow	6	3	0	1	0	4	3	17	2.4	3.0
Black-crowned Night Heron	0	2	1	6	5	0	0	14	2.0	2.5
Cliff Swallow	0	9	0	0	3	0	0	12	1.7	2.1
Gadwall	3	0	0	2	2	0	0	7	1.0	1.3
Sandhill Crane	0	2	0	0	2	0	0	4	.6	.7
American Coot	0	4	0	0	0	0	0	4	.6	.7
Barn Swallow	0	4	0	0	0	0	0	4	.6	.7
Western Meadowlark	0	1	0	1	0	0	2	4	.6	.7
Pied-billed Grebe	3	0	0	0	0	0	0	3	.4	.5
American Bittern	0	0	0	3	0	0	0	3	.4	.5
Great Blue Heron	0	0	(2)	0	0	0	0	2	.3	.4
Green-winged Teal	0	0	0	1	0	0	0	1	.1	.2
Virginia Rail	(1)	0	0	0	0	0	0	1	.1	.2
Sora Rail	0	1	0	0	0	0	0	1	.1	.2
Forster's Tern	0	1	0	0	0	0	0	1	.1	.2
Common Nighthawk	0	(1)	0	0	0	0	0	1	.1	.2
Brown-headed Cowbird	0	1	0	0	0	0	0	1	.1	.2
Vesper Sparrow	0	0	0	0	0	0	1	1	.1	.2
Total No. Species	13	23	12	17	17	7	7			
Total No. Individuals	225	252	229	285	214	60	40			

(Figure 7.01). The breeding success of Redheads was calculated because their broods were confined to one area and easily monitored. The fledgling success was estimated at 56%. Generally, most nests in the study sites were unsuccessful. By June 10th, all of the nests found in the study sites had eggs or nestlings (excluding the Long-billed Marsh Wren, of which we have no accurate nest records) or the nests were unoccupied and remained so throughout the summer. Many nestlings were found dead and other nests abandoned. Causes for nest failure could not be determined in most cases. However, human disturbances and a decrease in water levels leading to increased predation both seemed to play a role.

Table 7.03. Listing of nests found in the three study sites and Duck Pond (Figure 7.01) during the summer of 1976; showing number of nests per species and the outcome of the nests.

Location	Species	No. of Nests	Outcome
Study Site 1	Pied-Billed Grebe	1	One young
	Cinnamon Teal	1	Predated
	Mallard	1	Predated
	Killdeer	1	Predated
	Coot	1	Unsuccessful
	Red-winged Blackbird	3	Unsuccessful
	Yellow-headed Blackbird	3	Unknown
	Long-billed Marsh Wren	3	Unknown
Study Site 2	Mallard	1	Predated
	American Avocet	1	One young, disappeared
	Yellow-headed Blackbird	4	Unsuccessful
	Red-winged Blackbird	1	Unsuccessful
	Wilson's Phalarope	1	Unknown
	Unidentified	1	Unknown
Study Site 3	Pied-billed Grebe	1	Successful
	American Coot	1	Successful
Duck Pond	Redhead	5	56% fledgling success

Predation had serious effects on nesting. Many of the ground nesters suffered predation from what we feel were Long-tailed Weasels and skunks, both of which were seen in the area. Other birds may have also preyed on eggs, although this was not observed. Coyotes were observed feeding on young ducks, and duck feathers were found in a coyote's stomach. Cows seemed to play only a small role in trampling nests; a male American Avocet was killed and one of its eggs cracked by trampling cattle. However, this type of nest damage probably only occurs when the cows are frightened.

Our nesting studies were handicapped primarily by the late start of the field studies. Many species had begun nesting earlier than the beginning of our

study; a Snipe nest with four eggs was found on April 30, 1977.

Preferred habitats (plant associates) for nesting and feeding comprised part of the data collected during the nesting studies. Although this is elaborated upon in the annotated species list, Table 7.04 presents this data in relation to the plant communities as defined in Chapter 3.

Table 7.04. Habitats (plant associates) most used by bird species for feeding (F) and nesting (N). MHSSA, summer, 1976.

Species	Tule**	Sedges & Rushes**	Saltgrass & Alkali Flats	Sage-brush	Roadside & Pasture	Open Water
Ducks	N, F	N, F		N*		F
Wilson's Phalarope		N, F	N			F
Black Tern	N	N				N, F
Snipe	F	N, F			N	
Killdeer			N, F		N, F	
Willet		N, F			N	
American Avocet			N, F			
Black-necked Stilt		F	N, F			
Pied-billed Grebe	N, F					F
Virginia Rail	N, F	N, F				
Sora Rail	N, F	N, F				
American Coot	N					F
Red-winged Blackbird		N, F		F	F	
Yellow-headed Blackbird	N, F			F	F	
Brewer's Blackbird		F		N, F	F	
Savannah Sparrow			F	N, F	N, F	
Sage Thrasher				N, F		
Horned Lark			N, F	N, F	N, F	

* One nest each: Mallard, Gadwall, Cinnamon Teal
** Feeding in association with these plants was in small pools or along the water's edge.

Annotated Species List

Ninety-nine species, representing 33 families, were recorded in the MHSSA. The records consist of observations made in 1976 and 1977. Sight records from other areas of the Valley and valley foothills are not included in the above figures, but are included in this species list.

Each species has been given an abundance rating and status (breeding or other). All available records were used to compile this list. Because this list includes data from sources other than our field study the ratings may differ from that found in Table 7.01. Abundance is as follows:

No. of Individuals	Rating
30+	Very abundant
20 - 29	Abundant
10 - 19	Common
5 - 9	Uncommon
1 - 4	Rare

The status is as follows:

Breeder: Nest, eggs or young seen.
Probable breeder: Seen throughout the summer, but no nests recorded.
Valley resident: Resident of Sierra Valley outside the MHSSA.
Migrant: Species not found during the breeding season.

Pied-billed Grebe: (Abundant, Breeder)
Adults with young were seen in all deep water channels. The floating nests were constructed of Scirpus sp.

Eared Grebe: (Rare, Migrant)
One individual was seen in Region C (Figure 7.01) on May 24, 1977 in transition plummage.

White Pelican: (Uncommon, Migrant)
Eight individuals were seen on many occasions throughout April to June 20, 1977. One was found dead on the latter date.

Great Blue Heron: (Rare, Migrant)
Three were seen on July 5, 1976, and regularly thereafter.

Common Egret: (Rare, Migrant)
One individual was observed feeding along a road-side irrigation ditch in late August, 1976.

Snowy Egret: (Uncommon, Migrant)
Six individuals were seen in spring, 1977.

Black-crowned Night Heron: (Common, Probably breeding)
Many were seen throughout the entire summer, but no nests were found. The first fledged, immature bird was seen on June 27, 1976.

Least Bittern: (Rare, Migrant)
One individual was observed on May 8 and 14, 1977 along Dyson Lane.

American Bittern: (Common, Probably breeding)
Adults were present throughout the summer of 1976, but no nests were found. "Booming" was heard in the area and the previous year a nestling was photographed.

White-faced Glossy Ibis: (Uncommon, Undetermined)
One individual was seen on June 28, 1977 in Area B.

Canada Goose: (Abundant, Breeder; Very Abundant, Migrant)
Due to the early date in nesting only two pairs were observed in 1976 (in Region D). Egg fragments found in Area B indicated that they were breeding. Observations in the early spring of 1977 showed up to 12 pairs breeding in the area. Two nests were found, but no young were observed. In fall and spring, large migrant flocks alight in the area. Possibly two subspecies utilize the MHSSA. The winter status is unknown.

White-fronted Goose: (Abundant, Migrant)
Flocks of 27 were seen in November, 1976 and early spring, 1977, three miles north of MHSSA.

Snow Goose: (Abundant, Migrant)

A flock of 27 was seen in November, 1976, about three miles north of MHSSA. Mixed flocks of the three species of geese were seen in Region E in spring, 1977.

Mallard: (Abundant, Breeder)

Nests were often found and broods were seen along most channels in the MHSSA.

Gadwall: (Uncommon, Breeder)

Gadwall were present throughout the study in small numbers. Broods were mostly found in the more secluded areas south of Dyson Lane.

Pintail: (Abundant, Breeder)

Nests and broods were observed in many places. Observations in February, 1977 seem to indicate that migrant flocks stop over in the area.

Green-winged Teal: (Uncommon, Undetermined)

A few birds were seen occasionally throughout the summer. No nests or young were observed.

Blue-winged Teal: (Rare, Migrant ?)

Two males were seen in Study Site 1 in June, 1976; one pair was seen on May 14, 1977 and two males were seen on June 18, 1977.

Cinnamon Teal: (Abundant, Breeder)

Cinnamon Teal were the most common duck breeding in the MHSSA. Nests and young were often seen.

American Widgeon: (Uncommon, Migrant)

Pairs were seen in early spring, 1977.

Shoveller: (Uncommon, Migrant)

One individual, possibly a female, was seen in August, 1976. Pairs were seen in spring, 1977.

Redhead: (Common, Breeder)

Nests and young were associated with deep water. Six pairs bred in Region C (Duck Pond) except in late summer, when they moved near Region E.

Ring-necked Duck: (Uncommon, Migrant)

A few pairs were seen in Region C in early spring, 1977.

Bufflehead: (Rare, Migrant)

Two pairs were observed in April, 1976.

Ruddy Duck: (Uncommon, Breeder)

Three pairs were seen; one downy young was found and another two to three week-old was seen in Study Site 1. According to the California Water Resources Report (1973) and opinion of local duck hunters, this duck has been common in past years. The decrease in numbers is believed to be from the unusually dry conditions.

Common Merganser: (Rare, Migrant)

One pair was seen in Region E in spring, 1977 only. They possibly breed in the nearby mountains.

Turkey Vulture: (Uncommon, Valley resident)
Vultures were present throughout the study. Observations in February, 1977 seem to indicate that they also winter in the area.

Red-tailed Hawk: (Uncommon, Valley resident)
Many birds were seen throughout the summer. Nesting habitat is available in and around the Valley.

Swainson's Hawk: (Rare, Valley resident)
One individual was sighted occasionally throughout the summer.

Rough-legged Hawk: (Uncommon, Migrant)
A few Rough-legged Hawks were seen in early August. The species may winter in the Valley.

Golden Eagle: (Rare, Valley resident)
Adults and immatures were seen on occasion during the summer. Two immatures were seen in Antelope Valley and may possibly breed in that area.

Marsh Hawk: (Uncommon, Probable breeder)
Males and females were seen hunting in the marsh throughout the summer. They probably breed in or near the MHSSA.

Prairie Falcon: (Rare, Undetermined)
One was seen on September 20, 1976 near the southwest end of Sierra Valley.

American Kestrel: (Uncommon, Breeder)
Many individuals were seen and one pair nested in the MHSSA. February observations seem to indicate that these birds are year-round residents.

Sage Grouse
This species was never observed; however, they were recorded in the area (California Department of Water Resources, 1973).

Sandhill Crane: (Uncommon, Breeder)
Nine individuals were seen during the study. A nest was photographed by a local resident near Sierraville (Benner, pers. comm.). In 1977, a nest was found in the MHSSA, Region E. Grus canadensis tabida is not reported as breeding in Sierra Valley, thus indicating a breeding range extension.

Virginia Rail: (Uncommon, Breeder)
This rail was possible more common than recorded. One nest was found in the sedge-rush association and many juveniles were observed.

Sora Rail: (Uncommon, Breeder)
This rail, being very inconspicuous, was also probably more common than recorded. One nest was found in the tule association.

American Coot: (Very abundant, Breeder)
Many nests were observed and young were seen in most channels. Nests were in or near the tule association.

Killdeer: (Abundant, Breeder)
Nests were generally in the alkali and salt grass plant communities.

Black-bellied Plover: (Rare, Migrant)
This bird was seen once in April, 1977.

Common (Wilson's) Snipe: (Very abundant, Breeder)

Snipe were heard winnowing throughout the area through early July, after which only an occasional display was heard. Nests were found in areas of sedges and rushes.

Long-billed Curlew: (Rare, Migrant)

A small flock was seen feeding in the MHSSA in spring, 1977.

Spotted Sandpiper: (Rare, Undetermined)

One bird was seen in Region D along a dry mud bank in late June, on July 30 and on August 18, 1976. Nests were located in the Gold Lake area, about 20 miles west of the MHSSA.

Willet: (Uncommon, Breeder)

In June, 1976, a dead adult Willet was recovered from a channel north of Dyson Lane. It was banded on the wing and leg. Banding data and personal correspondence reveals the bird was banded at the Palo Alto Yacht Harbor (San Francisco Bay, California) by H.L. Cogswell and Paul Kelley on February 19, 1973. No other birds were seen with bands. Willets nested mainly in the sedge-rush community.

Yellow-legs: (Rare, Migrant)

Both Greater and Lesser Yellow-legs were seen in April, 1976, and one Greater on July 14, 1976.

Least Sandpiper: (Rare, Migrant)

One individual was seen in Region C late in July.

Western Sandpiper: (Rare, Migrant)

One individual was observed in late July.

Long-billed Dowitcher: (Rare, Migrant)

Four dowitchers were seen landing and feeding in Region C on July 19, 1976.

American Avocet: (Uncommon, Breeder)

Small numbers of Avocets attempted nesting in the MHSSA. One abandoned nest and one nest with two parents were observed on alkali flats near Study Site 2. The latter nest was unsuccessful. In late summer, small flocks of two or four were seen feeding.

Black-necked Stilt: (Uncommon, Breeder)

Small numbers bred mainly in Region B. One abandoned nest was found. No other nests were found; however, pairs defended territories throughout the summer. An increase in birds in Area B in late July including birds believed to be juveniles indicated that some pairs were successful.

Wilson's Phalarope: (Very abundant, Breeder)

Many nests and downy young were observed. By late July, most birds had gone. Juvenile birds could easily be distinguished from the adults and were seen together in large flocks by mid-July. The last Phalaropes seen were two immatures feeding in Region C on July 31, 1976. Nests were found in salt grass, sedges and rushes.

Northern Phalarope: (Rare, Migrant)

Two birds were seen in Region C in July. They flew in and landed for only a few minutes.

California Gull: (Uncommon, Migrant)
These birds are known to breed in the Modoc Plateau. They nest colonially on large lakes, so it is not likely that they nested in the valley.

Ring-billed Gull: (Uncommon, Migrant)
This bird also nests in the northeastern section of California, however as with the California Gull it did not nest in the Valley.

Forster's Tern: (Rare, Undetermined)
A single bird was seen occasionally throughout the summer. This bird is known to nest in freshwater marshes.

Caspian Tern: (Uncommon, Undetermined)
Immature and adult birds were seen in Region E in late July and August. We feel they did not nest in the MHSSA.

Black Tern: (Very abundant, Breeder)
These birds build floating nests using rushes (*Juncus* spp.) and sedges (*Carex* spp.) as supports. Black Terns formerly bred throughout California, however, their breeding range has diminished considerably; thus this population may be one of the few in California.

Mourning Dove: (Uncommon, Valley resident)
Doves were only seen a few times in the MHSSA, but were common in other parts of the Valley.

Great Horned Owl: (Rare, Valley resident)
No owls were actually seen or heard. The only evidence of this owl was from feathers and pellets found in the area and another feather found on a fresh Willet kill. Both feathers were identified by comparison with museum specimens. Owls were seen in the Valley near the MHSSA in June 1977.

Screech Owl: (Rare, Valley resident)
A dead owl was found in the MHSSA in June, 1977.

Burrowing Owl: (Rare, Valley resident)
Burrowing Owls were seen in many burrows throughout the sage areas of the Valley. One dead specimen and a few individuals were seen in the MHSSA. No burrows were found in the study area.

Poor-will: (Rare, Valley resident)
One dead bird was recovered on August 18, 1976 at 5000 feet (on the east slope). The specimen showed evidence of moulting. No birds were seen in the Valley, but they may feed in the vicinity.

Common Nighthawk: (Uncommon, Valley resident)
Nighthawks were seen feeding over the MHSSA throughout the summer. We feel confident they nest in the Valley.

Vaux's Swift: (Hypothetical)
This species was not seen during the study. One specimen was collected in June, 1916 by J. Maillard.

Anna's Hummingbird: (Rare, Migrant)
One dead bird was found in Sierraville on August 19, 1976. In August,

unidentified hummingbirds were seen flying throughout the MHSSA at a good speed five to ten feet above the ground.

Belted Kingfisher: (Rare, Undetermined)
One individual was seen sitting on the steel bridge. An individual seen in various locations in the Valley was thought to be that same individual.

Western Kingbird: (Rare, Migrant)
One bird stayed in the MHSSA for two weeks, in the latter part of July.

Say's Phoebe: (Hypothetical)
None were seen, but J. Maillard collected one specimen in June, 1916.

Horned Lark: (Abundant, Breeder)
Large numbers were seen throughout the summer. Non-fledged young were often observed.

Violet-green Swallow: (Uncommon, Valley resident)
They were seen occasionally throughout the summer though slightly larger numbers were seen in the earlier and latter parts of the summer. Fledged young were seen and other evidence leads us to believe that this species bred in the Valley.

Tree Swallow: (Rare, Undetermined)
A few were seen in the latter part of July.

Bank Swallow: (Rare, Valley resident)
Very few were seen, though fledged young were seen in July. We feel it is possible that they bred in the Valley.

Rough-winged Swallow: (Uncommon, Valley resident)
Small numbers were seen, but breeding status could not be determined.

Barn Swallow: (Very abundant, Breeder)
Large numbers built their nests almost exclusively under the small bridges along Dyson Lane. A fledged juvenile was found in the stomach of a garter snake. Eggs and fledglings were seen throughout July.

Cliff Swallows: (Very abundant, Breeder)
Very large numbers nested on and under the steel bridge. Numbers seemed to decrease in late July before the Barn Swallow numbers decreased.

Black-billed Magpie: (Uncommon, Valley resident)
This is a common bird of the sage areas of the Valley. Many pairs were seen in the adjacent sage areas of the MHSSA. Even though no birds were seen preying on young or eggs, we feel that some predation was from these birds. On one occasion, a Magpie was seen attempting to eat a snake.

Common Raven: (Uncommon, Valley resident)
Ravens were seen throughout the summer in the Valley. Not until late July did they land in the MHSSA with regularity.

Common Crow: (Uncommon, Valley resident)
Crows were seen in the Valley throughout the summer, however none were seen to land in the MHSSA. Their presence was always greeted by defense responses from the three species of blackbirds.

Long-billed Marsh Wren: (Abundant, Breeder)
Nesting was primarily in the tule association. Decreases in numbers were noticed in November.

Sage Thrasher: (Uncommon, Breeder)
A few birds bred in sagebrush areas bordering alkali and "marshy" areas. This bird is exclusive to the sagebrush.

Western Bluebird: (Uncommon, Undetermined)
Bluebirds were infrequently seen throughout the summer, having greater frequency in April and early June than any other time.

Mountain Bluebird: (Uncommon, Undetermined)
Very few were seen during the summer.

Water Pipit: (Uncommon, Migrant)
They were seen only in April.

Bohemian Waxwing: (Undetermined)
These birds are known in the Valley as well as in the Great Basin. A flock was reported in nearby Loyalton the previous year, however we did not see any during the study.

Shrikes: (Rare, Undetermined)
No Northern Shrikes were seen; however, the valley is within its range. A Loggerhead Shrike was seen on sage adjacent to a barn just outside the MHSSA. They do breed, or at least formerly did in the Valley (Belding, 1890).

Starling: (Uncommon, Valley resident)
Nests and young were found in abandoned barns. These were seen throughout the summer and a flock was seen in February, 1977. The latter indicates that a population may winter in the Valley.

Orange-crowned Warbler: (Rare, Migrant)
An unconfirmed sighting was made of a bird we believe was an Orange-crowned Warbler, which was seen in low willows on the roadside, in mid-August.

House Sparrow: (Uncommon, Valley resident)
This bird was common around ranches and towns.

Western Meadowlark: (Common, Breeder)
They were primarily seen in sage and grassy areas.

Yellow-headed Blackbird: (Very abundant, Breeder)
A large population bred exclusively in the tule and sedge-rush associations preferring the tule association. In late July, large mixed flocks (three species of blackbirds, cowbirds and starlings) of 100 or more birds were seen feeding together. The birds congregated around the legs of cattle; perhaps because the cattle stirred up insects while feeding.

Red-winged Blackbirds: (Very abundant, Breeder)
Most birds nested in rushes and sedges. Males and females were observed tending nests. Large numbers of nests were found. In July, after much of the vegetation had been grazed, nests could be seen above the surrounding stumps. Most birds observed were believed to be _Agelaius phoeniceus nevadensis_ (race identified from one specimen).

Tricolored Blackbird: (Uncommon, Undetermined)
A few birds were observed in April; however, a few unconfirmed sightings seemed to indicate their presence during the summer. Tricolor's are known east of the Modoc Plateau.

Brewer's Blackbird: (Very abundant, Breeder)
They tended to nest exclusively in sage. Their numbers were less than both the Yellow-headed and Red-winged Blackbirds. One nest was found to have been parasitized by a Brown-headed Cowbird. The nest, with one Cowbird's egg and three Brewer's eggs, was discovered in July.

House Finch: (Uncommon, Probably breeding)
Two pairs of House Finches were seen regularly in the MHSSA. They were most frequently seen near ranch houses.

Savannah Sparrow: (Common, Breeder)
It tended to frequent the more arid sections and salt grass flats. A nest and eggs were found in a small depression on the ground.

Vesper Sparrow: (Uncommon, Probably breeding)
Only a few birds were seen throughout the summer. They prefer the more arid sections where, we feel, they nested. Because of their inconspicuous habits, they may be more abundant than we found.

Sage Sparrow: (Hypothetical)
We did not observe them anywhere in the Valley, however, we feel it may have been our missight. Grinnel and Miller (1944) indicate it breeding in the Great Basin region south to Sierra County.

Chipping Sparrow: (Uncommon, Valley resident)
It was seen only in the foothills of the Valley in sage adjacent to coniferous forests.

Brewer's Sparrow: (Uncommon, Probably breeding)
It was seen throughout the summer. We feel very confident the bird bred in the MHSSA, even though no nest was found.

White-crowned Sparrow: (Uncommon, Migrant)
This sparrow was only seen in November, in the roadside vegetation, feeding on the ground. These birds are most likely migrants.

Song Sparrow: (Uncommon, Undetermined)
This sparrow was only seen in August and November in any numbers. Any winter records are unknown, therefore, from just these sight records we are unable to determine its status. Maillard (1919) found _Melospiza melodia fishella_ breeding in the Valley.

DISCUSSION

In the early part of our study large numbers of individuals of many species were present. A steady increase in the numbers of individuals was seen from early June through July, after which time numbers of most species began to rapidly

decrease (Table 7.02). Many broods of ducks as well as fledgling shorebirds disappeared. Because of such decreases, the abundance indicated for each species is probably lower than this marsh can support in a wetter year.

A possible reason for such rapid decreases in numbers is the departure of birds for their winter ranges. This is the case for the Wilson's Phalarope and the Black Tern, which are expected to leave by mid-July (Stout, 1967). However, this was not expected with other species. Decreases in water level coincided with the decreases in the populations (Chapter 2). Even though water levels have not been monitored in previous years, local residents and ranchers indicated that the water table in the valley had dropped some 60 to 80 feet in the last year and the above-ground water was low in comparison to "normal". Although some seasonal decrease in water level is normal in Area B, it certainly is not common in other areas monitored through the road counts. Here the same population increase was observed, with the following rapid decrease after mid-July. Weller, et al (1958) found decreases in the bird population of a marsh in Utah due to lack of water and over-grazing by cattle. Apparently the sudden decreases in our bird populations may have been effected in a similar fashion. A possible indicator of change in habitat is the Ruddy Duck, a deep water species. The California Water Resources Report (1973) and opinion of some duck hunters from Sierra Valley indicate that this species is common in most years. During our study only one nest and three pairs were recorded. Weller, et al (1958) found that Ruddy Ducks are affected greatly by fluctuating water levels and Low (1951) mentioned that open water is of particular importance to the Ruddy Duck's choice of breeding habitat.

The lack of breeding success and high mortality of other water birds may also be attributed to the lack of water and over-grazing exhibited during the summer of 1976. As the water dried and isolated ponds were formed in place of normally full irrigation ditches, juvenile birds and birds in eclipse plummage were isolated without vegetative cover. It is our feeling that increased mammal predation played a major role in the decline of the bird population.

The bird count data also allowed us to look at the populations of similar birds. It is suggested in Figures 7.03, 7.04 and 7.05 that birds with similar habitats and, or, food requirements may partition their niches by spacing the times they begin nesting and hence the time their numbers reach their maximum. The Pintail and Cinnamon Teal populations peaked at different times, as did the two abundant swallows and the three blackbirds. The Cliff Swallows arrived in the marsh before the Barn Swallows, therefore, not only did they begin nesting earlier, they also had first choice for nest sites. The Yellow-headed Blackbirds arrived in the marsh and were setting up nest territories in the tules by mid-April. The Redwings arrived later and nested in sedges and rushes, with the Brewer's Blackbirds arriving last and using the sage and grassland habitat for nesting, which at that time was all that was left.

Food availability did not appear to be a problem in the early summer. Waterfowl prefer vegetable food except in summer, when animal food increases. Pondweed (Potamogetonaceae) and sedges (Cyperaceae) are the main diet of the Mallard, Pintail, Cinnamon Teal and Gadwall (Mabbot, 1920). Both families of plants were found in abundance in the MHSSA. Insects were also readily available in all habitats. However, during the latter part of the summer the decrease in water and grazing pressure by cattle caused an enormous decrease in vegetable food. Aquatic plants withered and those left were foraged by cattle. However,

any effects this had on herbivorous birds were impossible to assess. On the other hand, the drop in water level exposed large numbers of fish and tadpoles, which are relished by the large wading birds (American Bittern and Black-crowned Night Heron).

Many of the birds nesting in the MHSSA arrive in the marsh prior to the spring vegetative growth of the marsh plants. Many of these birds rely on year-old plant material to build their nests (e.g. Yellow-headed Blackbird, Long-billed Marsh Wren, Black Tern and Pied-billed Grebes). By the end of August, heights of the tules, sedges and rushes were only from four inches to one foot, because of heavy grazing. It was known that vegetative reproduction of these plants was beginning by August, however without sufficient water this may have been unsuccessful, therefore having an effect on the next year's breeding populations. However, observations in April, 1977, showed water levels in the marsh to be close to those observed in 1976 and that the height of the vegetation was also comparable. Some effects of the drought and habitat destruction cannot be reversed in one year and unfortunately the drought continues; however, the underground water filling the Sierra Valley marshes is providing a marsh habitat for nesting birds even under these adverse conditions.

SUMMARY

Ninety-nine species of birds, representing 33 families, were observed. Thirty-one species were found to have bred and nine others probably bred in the MHSSA. An increase in the numbers of birds was seen through early July, after which an abrupt decrease in the total number of individuals and species occurred. Although some birds (e.g. Wilson's Phalarope, Black Tern and Common Snipe) left the marsh in late July due to having finished breeding, the decrease in waterfowl at this time (including ducklings) was probably due to unusually early decreases in the areas of standing water and vegetative cover. In fact the early drying of waterways, complicated by extensive grazing by cattle, seemed to correlate with a high frequency of nesting failures among shorebirds and waterfowl. Apparently predation by such mammals as coyotes, weasels and skunks was favored by these conditions.

Several species found breeding in the Sierra Valley marshes are worth special note. Many of these birds are remnants of previously flourishing populations which have gone the way of other California marshes. The Black Tern, once common throughout California, is now restricted to an uncertain range, but a large population exists in Sierra Valley. This area may be one of its most southern breeding areas in California. The Greater Sandhill Crane, a threatened species, was found breeding in the valley and the MHSSA. They have never been recorded breeding in Plumas County. This area might be the southernmost limit of the breeding ranges of the Wilson's Phalarope and Redhead. The Sierra Valley Marsh is one of the few remaining eastern marshes in California that supports breeding populations of these birds.

CHAPTER 8
MAMMALS

INTRODUCTION

The mammal study was carried out in conjunction with the bird study, by two researchers. Observations were made in early April and June, July and August of 1976. The purpose of the study was to gather baseline survey data on the mammals of the Marble Hot Springs Study Area.

METHODS

Initial trapping was carried out during the first week of July. The study area was separated into three general habitats: sagebrush, saltgrass and wetland areas (rushes, sedges and shallow standing water). Each habitat was sampled separately, over a period of three nights. This course of action was chosen not only to identify mammal species but also to determine habitat preferences and in which areas mark-and-recapture studies were feasible.

Trap lines consisted of 20 trapping stations set approximately 16 meters apart with three traps at each station (two Hav-a-Hart, size 00, and one Sherman, mouse size). Each trap was baited with a mixture of peanut butter and rolled oats.

The above method was also used for mark-and-recapture studies of _Peromyscus maniculatus_. Mice were caught, marked on the tail and feet with non-toxic, permanent ink and released. The recapture of marked animals continued for three consecutive nights, along each trap line.

Attempts to live-trap larger mammals in Hav-a-Hart traps (sizes 0-8) were unsuccessful, although a variety of baits were used, such as trout, rotting meat, eggs and fish oil (Anderson, 1948). Therefore all statements on these animals are based on observational data and collection of dead specimens.

A study was also made of the bats feeding in the marsh. Mist nets were set up on several evenings to do a mark-and-recapture study of the bat populations, however no bats were caught. The marsh is extremely flat and totally void of trees; perhaps because of this the bats easily avoided the nets. Thus in order to identify the species of bats in the marsh it was necessary to shoot them. A 20-gauge shotgun with number nine shot was used.

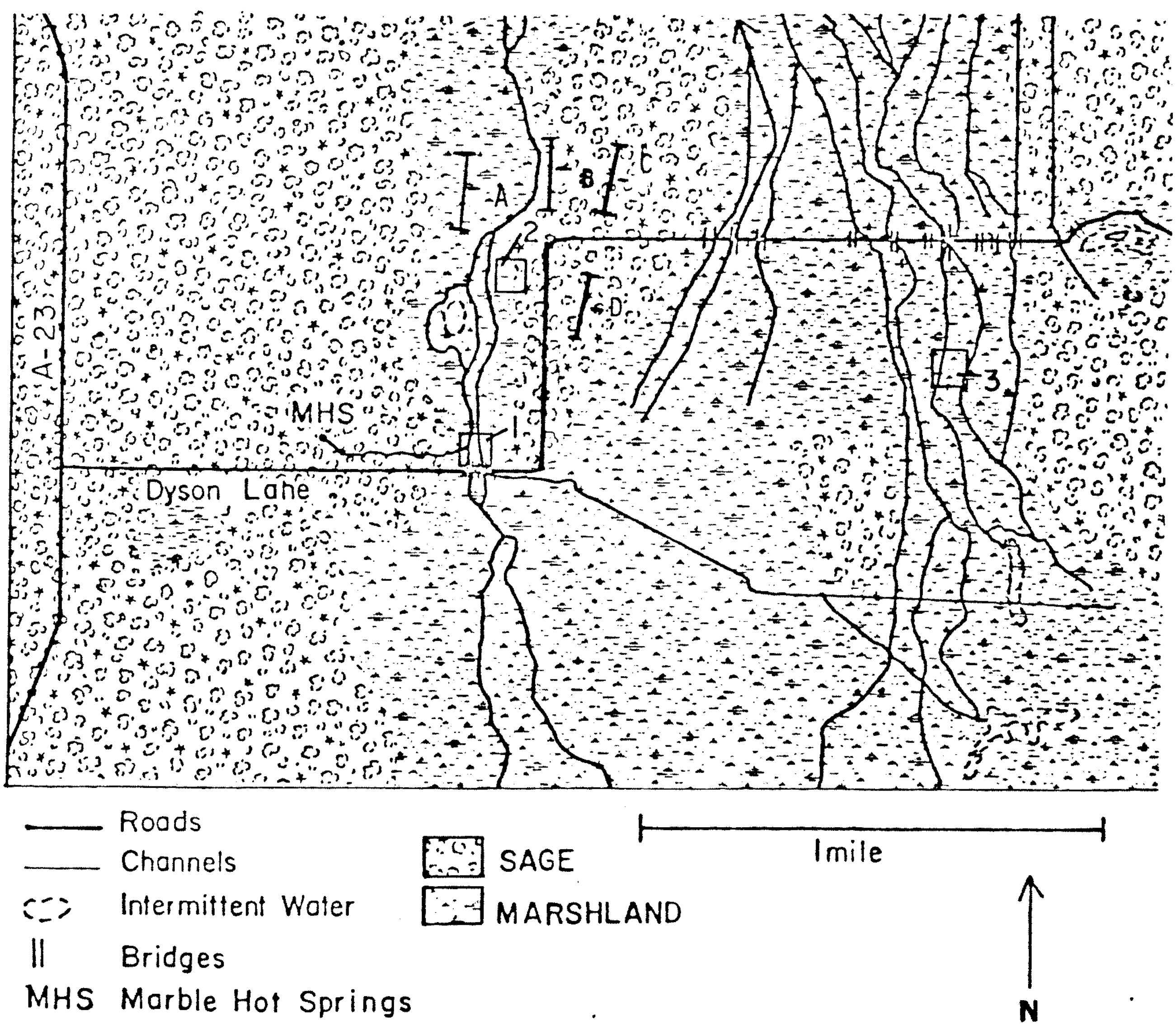
RESULTS

The results of the first trapping efforts showed three species of small mammals in the marsh, with strict habitat preferences. _Peromyscus maniculatus_ was found in the sagebrush and saltgrass habitats, with _Microtus montanus_ and _Sorex vagrans_ occupying the wetland areas. The number of animals trapped each night showed that a mark-and-recapture study was feasible only on _P. maniculatus_.

Two mark-and-recapture studies on _Peromyscus maniculatus_ began on July 21 (Table 8.01). Trapping continued for three consecutive nights, when the catch consisted of 50% marked and 50% (new) unmarked animals. Data was analyzed with Schumacher and Eschmeyer's formula for mark-and-recapture, as presented by Lagler (1956). Confidence limits (95%) for P (population estimate) using the last day's catch were also calculated (Cox, 1976).

The first mark-and-recapture trapping sequence (July 21 through July 23, 1976) took place in an area of dense sagebrush east of Study Site 2 (Figure 8.01). For this trapline P = 85, with 95% confidence limits of P being 62-146. The second trapping sequence was run from August 12 through August 14, 1976, directly

Fig. 8.01. Map of the Marble Hot Springs Study Area showing placement of traplines used in the mammal study. A= trapline for sampling wetland habitat, B= alkali flat/salt grass habitat, C= sagebrush and trapping sequence #1, D= trapping sequence #2. (July through August 1976).



south of the first on the south side of Dyson Lane (Figure 8.01). This area was also totally composed of sagebrush, however the plants were not as dense as in the first area. For this area P = 27 with 95% confidence limits for P lying between 19 and 56. This is to say that the traplines were drawing from populations of 85 (1) and 27 (2). The actual area sampled is unknown and a density figure for these areas cannot be calculated.

Table 8.01. Mark-and-recapture data for two trapping sequences (July and August, 1976) for Peromyscus maniculatus. (M = marked; UM = unmarked; TM = marked recaptures; TC = total catch).

Trapping sequence 1				
Date	M	UM	TC	TM
21 July	0	29	29	0
22 July	10	16	55	10
23 July	14	14	83	24
Trapping sequence 2				
Date	M	UM	TC	TM
12 August	0	7	7	0
13 August	5	8	21	5
14 August	7	7	35	12

An attempt was made to include mark-and-recapture data for Peromyscus maniculatus in the saltgrass area. A trapline was set out on July 26 and July 27, 1976. Both times when the traps were checked in the morning several of them had been damaged (10% on the first night, 20% on the second) by cows walking through the area. This loss of traps would have seriously biased our data so the trapline was removed from the area. One interesting event did occur on the second night of trapping in this area. A mouse was caught which had been marked three days earlier from the first trapping sequence in the sagebrush. This trapline was approximately 300 meters from the trapline in the saltgrass area.

Annotated List of Mammals

A total of 12 species of mammals were found, in 1976, to reside in the marsh area and to utilize its resources. Two additional species were seen by a class from San Francisco State University in May, 1977; these were represented by one porcupine and a beaver that was seen in Duck Pond (east of the easternmost bridge in Figure 8.01). Comments on the activities and habitat preferences of the 12 animals seen in 1976 are based solely on observations made between April and August, 1976.

Sorex vagrans (vagrant shrew)

Three shrews were trapped in areas of wet grassland (mixed sedges and rushes) on the periphery of shallow ponds, during the first week of July, 1976.

Eptesicus fuscus (big brown bat)

Lasionycterus noctivagans (silverhaired bat)

Both species of bats could be observed flying over the marsh at dusk and would continue until about 10:00 p.m., or until the temperature dropped sufficiently to curtail both the activity of the bats and the night-flying insects. Three specimens were shot (2 big brown bats and 1 silverhaired bat) for identification during the latter part of July.

Mustela frenata (longtail weasel)

The first weasel was sighted in the morning sometime during the first week of August. Its burrow was located in the sagebrush near the southern outlet of the Marble Hot Springs. Shortly after this sighting another occupied weasel burrow (formerly occupied by a muskrat) was located southeast of the steel bridge on the edge of a dry channel. These diurnal observations coincide with the beginning of the breeding season of the longtail weasel (Burt, 1964). The weasel is normally a nocturnal animal and is a primary suspect of predation on duck nests in the area of these burrows.

Mephitus mephitus (striped skunk)

Taxidea taxus (badger)

Both of these animals were sighted only once during the summer of 1976. Their presence suggests their role as predators in the marsh.

Canis latrans (coyote)

Coyotes were sighted almost daily throughout the summer in the marsh area, usually hunting in the surrounding grassland. One juvenile and one adult (male) were collected. Both were road kills. Stomach analysis was carried out on the adult, the contents being four Microtus, two garter snakes and one duck.

Ondatra zibethica (muskrat)

The muskrat is perhaps the most obvious mammal in the marsh. They were active in early April and remained visible throughout the summer. Early morning and late afternoon were the times when the most muskrats could be seen, however activity was apparent throughout the day. The tule houses characteristic of this species were not found in the marsh areas. As the water level dropped extensive burrow systems were exposed, some even having entrances in the centers of waterways. Although houses were not evident, muskrats were seen dragging Typha latifolia (cattails) into their burrows. Observations showed that the muskrats enjoyed a diet of the soft aquatic plants growing in deep water. As the water level dropped muskrats could be seen walking overland to other areas with water and sitting and eating the exposed aquatic plants in the dry channels. Young muskrats were seen in the company of adults from the beginning of July. Two juveniles were trapped in fish traps full of tadpoles and catfish during July.

It is very probable that the muskrat population in Sierra Valley is native and not an extension of the introduced populations in the Central Valley of California (Hensley, 1946).

The muskrat is considered a pest animal by the ranchers because of the damage the burrows cause to the irrigation systems. It is not unusual then for the ranchers to hire trappers during the winter months to decrease the population (Wiley, 1976).

Citellus beldingi (Belding ground squirrel)

The Belding ground squirrel population is centered around Dyson Lane on the west and east end of the steel bridge. The squirrels have used the loose dirt edges of the road and the road cuts to excavate their burrows. The squirrels were active in mid-April through July of 1976. By the end of July all squirrels were back in their burrows. During the summer no juveniles were observed.

Peromyscus maniculatus (white-footed deer mouse)
Microtus montanus (mountain vole)

These are the most numerous mammals in the marsh area. Peromyscus maniculatus is found in the sagebrush and saltgrass areas. Microtus montanus is found in wetland areas in close association with water. Microtus were observed frequently during the day.

Sylvilagus nuttalli (mountain cottontail)

Rabbits were far from abundant in the Marble Hot Springs Study Area. After the harvest of the grain fields a few rabbits were seen on the edges of Dyson Lane. The areas surrounding the study area are grain fields and pastureland habitats which could support a large number of rabbits. This situation suggests that some type of control measure had been in effect; however, all attempts to question residents on this matter were fruitless.

DISCUSSION

This investigation focused on the small mammal species in order to evaluate their potential as a food source. The marsh supports a number of predatory birds and mammals, and their numbers are largely dependent on the small mammal (mainly rodent) populations. Peromyscus maniculatus is the most numerous rodent in the marsh area. The difference in trap line population estimates in the two areas of sagebrush can be attributed to several factors. (1) The amount of vegetative cover in the first area was extremely dense, therefore the animals would not have been as visible to predators while active, whereas the second area was relatively sparse. (2) The first trapping sequence was done three weeks before the second and the difference in weather conditions may have caused a decrease in activity. August was cooler and rainy while July was hot and dry. (3) The phase of the moon may have affected activity. However, the second trapping sequence took place during the new moon, which should have promoted, not lowered, the number of active mice. These are primarily nocturnal animals and are less subject to predation with less light.

Over the course of the summer, sandhill cranes, marsh hawks and coyotes were seen hunting in the sagebrush during the day. It is thought that Peromyscus might have been an integral part of their diet.

Microtus montanus is also an important food source. This was demonstrated by the stomach analysis of the coyote and from observations made on coyotes during the day. The diurnal activity of Microtus makes these voles available for crepuscular and diurnal predators.

The scarcity of rabbits in the marsh area cannot be explained. Habitat availability suggests that the area could support a substantial number of lagomorphs. It is suspected that some type of control method has been carried out in the recent past to decrease rabbit populations because of damage done to grain crops.

Coyotes far outnumber any other mammalian predator in the marsh area. Their boldness during the daytime and the evidence of the one stomach analysis suggests that during the summer months the environment can support their numbers. During the summer the only coyotes found dead were road kills. However, during September, October and November of 1976, coyotes were seen shot and hung on barbed wire fences of ranches in Sierra Valley (a practice not uncommon in California). The ranchers do have problems with coyotes if the weather turns cold before the

fall calving. It is during this time that coyotes are shot.

Evidence suggests that the Marble Hot Springs Study Area is able to support a thriving mammal population. There was no evidence of unhealthy animals or unusually low population numbers except in the case of the rabbits. However, this initial investigation does suggest that the study area may be able to support greater densities of small mammals than were found in 1976. Low densities may have been due to diminished cover resulting from intense grazing and lack of water.

SUMMARY

Twelve species of mammals were found during the summer of 1976 in the MHSSA. *Peromyscus maniculatus* was the most numerous rodent in the area, occupying the sagebrush and saltgrass habitats. *Microtus montanus* was another abundant rodent, occupying wetland areas. The muskrat (*Ondatra zibethica*) was the most frequently seen mammal in the marsh area. Other mammals in the marsh area included: *Sorex vagrans*, *Eptesicus fuscus*, *Lasionycterus noctivagans*, *Mephitus mephitus*, *Taxidea taxus* and *Sylvilagus nuttalli*.

Two predators were active in the marsh area. The longtail weasel (*Mustela frenata*) appeared to be an important predator at duck nests. The coyote (*Canis latrans*) was an ever present member of the marsh's mammal community. Stomach analysis of one individual suggested a diet of *Microtus* sp., common garter snakes and duck.

CHAPTER 9
SUMMARY AND DISCUSSION

This study took place in the Marble Hot Springs area (MHSSA) of Sierra Valley, Plumas County, California. This Valley lies east of the crest of the Sierra Nevada at an elevation of approximately 4,850 feet. The average annual precipitation is less than 20 inches (most of it falling as snow), but in spring extensive marshes form that drain into the Middle Fork of the Feather River. The objectives of the 12-person study team were to evaluate the marsh in the MHSSA as a wildlife habitat, and to provide a baseline description of the marsh. Accordingly the summer of 1976 was spent surveying macroscopic plants and animals and measuring physical parameters of the environment.

Physical Parameters

The average daily maximum temperature was 27.5 C and the average daily minimum was 3.5 C. The relative humidity averaged less than 25 percent during the afternoon. The amount of precipitation was well below average during the preceding spring and winter. Consequently, water levels in the marsh dropped rapidly during June and one (Site 2) of the three Study Sites had completely dried up by the end of July. However, August was extraordinarily wet; 1.78 inches of rain fell and water levels rose in the marsh.

Analysis of the water showed a high (11 ppm) to low (3 ppm) oxygen concentration that varied with time and place, while water temperatures varied from 8.5 C to 24 C. The water was alkaline at all sites and one site had chloride and dissolved solid concentrations that exceeded standards for drinking water.

Plants

The important plant associations were: sagebrush scrub; salt grass; tule, sedges and rushes; and aquatic plants. The higher plants, collected from all areas, numbered 146 species from 43 families. Vegetation analysis by point-intercept, line transects on specific sites within the marsh and salt flat habitats showed the dominant plants to be *Distichlis spicata* and members of the Cyperaceae and Juncaceae, including *Eleocharis* spp., *Juncus* spp., *Carex* spp., and *Scirpus americanus*. In some areas with large expanses of water the aquatic plants found to be dominant were: *Potamogeton* spp., *Elodea canadensis*, and *Myriophyllum* spp.

In Study Sites 1 and 3 the aquatic and marsh plant cover decreased significantly from June to August. In Study Site 2, where plant cover did not change significantly, the plants decreased drastically in height. Observations of flowering in *Typha latifolia* showed the majority of spikes to be unsuccessful, withering and drying before maturity. The early blooming and drying of the marsh plants were probably related to the drought. Reduced amounts of standing water and preferred forage plants increased the grazing done by cattle on the marsh vegetation.

Arthropods

Thus far, at least 452 species, representing at least 154 families, of arthropods have been identified from the collected material.

Aquatic sampling, using light traps and dip nets, yielded about 6,500 specimens, representing at least 86 species and 35 families. Specimens of *Daphnia* (Crustacea: Cladocera), although taken in only a few catches, comprised 37 percent of the total collection. Eight percent of the total were mayflies, with *Callibaetis* sp. (Ephemeroptera: Baetidae) dominant (99 percent).

Sampling with flight traps yielded about 11,000 specimens. Of these, 57 percent were midges (Diptera: Chironomidae). Of three species of *Dolichopus* (Diptera: Dolichopodidae), *D. idahoensis* comprised 89 percent of the total. Mosquitos were not abundant during the summer of 1976.

Of the almost 9,000 arthropods tallied thus far from pitfall collections, spiders, carabids (Coleoptera: Carabidae) and staphylinids (Coleoptera: Staphylinidae) dominated. The relative lack of abundance of arthropods in Study Site 3 may have been the result of overgrazing by cattle in that area.

Fish

Although eight species of fish were collected, greater than 50 percent of the individuals at any one sample site consistently fell within the confines of only one species. Such a pattern may indicate a stressful environment.

The most abundant fish was the brown bullhead, *Ictalurus nebulosus*; however its absolute dominance was achieved only in the waterways having a comparatively reduced vegetation, a substrate with some sand and a moderate to sluggish waterflow. The carp, *Cyprinus carpio*, was found in densities inversely correlated to the conditions preferred by the brown bullhead. The one game fish found in abundance was the largemouth bass, *Micropterus salmoides*. The abundance of this fish was directly correlated to a high density of forage fish, *Notemingonus crysoleucus*, and a corresponding low density of aquatic vegetation. Game fish were not found in areas where water level fluctuation was greater than 100 cm and where the substrate was without sand or gravel.

An unusual weight-length relationship was found in specimens of brown bullheads greater than 150 mm, where they proved to be shorter at any given weight than those reported in the literature. They also became reproductively mature when relatively short. The overall impression is of a population of fish experiencing some type of environmental stress, and expressing it in growth and maturation abnormalities.

Amphibians

Rana catesbeiana, the bullfrog, was the only species of amphibian found in the MHSSA during the summer of 1976. The adult population was low and apparently not in good reproductive condition. However tadpoles were numerous; most tadpoles that had overwintered were 8-11 cm long in June. Some metamorphosed in mid-July; while newly hatched tadpoles (2-3 cm in length) were found in mid-August. Tadpoles suffered heavy mortality from dessication in drying pools, as well as from predation by garter snakes and birds.

Reptiles

The Valley Garter Snake, *Thamnophis sirtalis fitchi*, was the only reptile in the marsh area. Habitats for this snake included waterways for feeding, with bushes, rockwalls and ground squirrel burrows providing cover. Food consisted mainly of tadpoles with fish, birds and carrion also included in the diet. There was no change in abundance of snakes from June through August (about 35 snakes were active at any one time), but few snakes were active in October and none in November. Females were about three times more numerous than males. The mortality of these snakes could be attributed primarily to large birds, cars and coyotes.

Birds

Ninety-nine species of birds, representing 33 families, were observed. Thirty-one species were found to have bred and six others probably bred in the MHSSA. An increase in the numbers of birds was seen through early July, after which an abrupt decrease in the total number of individuals and species was observed. Although some birds (e.g. Wilson's Phalarope, Black Tern and Common Snipe) left the marsh in late July due to having finished breeding, the decrease in number of waterfowl at this time (including ducklings) was probably due to unusually early decreases in the areas of standing water and vegetative cover. In fact, the early drying of waterways combined with extensive grazing by cattle seemed to correlate with a high frequency of nesting failures among shorebirds and waterfowl. Apparently predation by such mammals as coyotes, weasels and skunks was favored by these conditions.

Several species found breeding in the Sierra Valley marshes are worth special note. Many of these birds are remnants of previously flourishing populations which have gone the way of other California marshes. The Black Tern, once common throughout California, is now restricted to an uncertain range, but a large population exists in Sierra Valley. This area may be one of its most southern breeding areas in California. The Greater Sandhill Crane, a threatened species, was found breeding in the valley and the MHSSA. They have never been recorded breeding in Plumas County. This area might be the southernmost limit of the breeding ranges of the Wilson's Phalarope and Redhead. The Sierra Valley Marsh is one of the few remaining eastern marshes in California that supports breeding populations of these birds.

Mammals

Twelve species of mammals were found during the summer of 1976 in the MHSSA. *Peromyscus maniculatus* was the most numerous rodent in the area, occupying the sagebrush and salt grass habitats. *Microtus montanus* was another abundant rodent, occupying wetland areas. The muskrat (*Ondatra zibethica*) was the most frequently seen mammal in the marsh area. Other mammals in the marsh included: *Sorex vagrans*, *Eptesicus fuscus*, *Lasionycterus noctivagans*, *Mephitus mephitus*, *Taxidea taxus* and *Sylvilagus nuttalli*.

Two predators were active in the marsh area. The long-tailed weasel (*Mustela frenata*) appeared to be an important predator at duck nests. The coyote (*Canis latrans*) was an ever present member of the marsh's mammal community. Stomach analysis of one individual suggested a diet of *Microtus* sp., common garter snakes and duck.

Discussion and Recommendations

The information generated by this study has provided a baseline description of the plants, animals and physical parameters of the marshes in the Marble Hot Springs area of Sierra Valley during the summer of 1976—a period when drought and intensive cattle grazing appeared the most important factors affecting these marshes. Consequently it may now be possible to evaluate the impact of future changes in the marsh environment, whether these be the result of changes in weather or land-use practices.

In order to provide a baseline that applies to a broader range of conditions, we would recommend that a study such as this be conducted during a year with a normal amount and distribution of precipitation. It would also be highly

desirable to be able to describe and evaluate these marshes during other seasons in addition to summer. Future studies should begin at least by late April in order to measure the nesting efforts and productivities of the birds as well as the populations of insects such as mosquitos. In the autumn certain animals, such as carp and bullfrog tadpoles, tend to aggregate in those waters that are warmed by the hot springs. It would be very interesting to study the animal populations that take advantage of these warmer waters during the winter; we suspect that this habitat may be important to wintering waterfowl.

In addition to providing baseline data for the MHSSA, this study has shown that, although 1976 was an unusually dry year, these marshes are a valuable habitat for wildlife. Because of its diversity of wildlife and accessibility to students, the Marble Hot Springs area is also valuable as a site for research, teaching and general appreciation of nature. Numerous studies could be conducted in the hot springs concerning questions of physiological ecology of vertebrates and invertebrates, as well as microbial ecology.

Finally, our observations in the Marble Hot Springs area of Sierra Valley pursuade us to endorse whole-heartedly the following recommendation (Calif. Dept. of Water Resources, 1973, p. 205), "Persons engaged in planning for this region should seriously consider the benefits of establishing an ecological reserve to protect the natural resources of the Marble Hot Springs area. Creation of such a reserve and careful zoning of adjacent lands for compatible uses could result in a distinct and unusual community asset of statewide and even interstate significance."

APPENDIX I

Annotated List of Plant Species, Marble Hot Springs Study Area, Sierra Valley, California, June through August, 1976.

	Abundance (A)	Habitat (H_1)	Habit (H_2)	Geographic Distribution (GD)
Marsiliaceae				
Marsilia mucronata (Four Leaf Water Fern)	O	SW	L	NA
Typhaceae				
Typha latifolia (Cattail)	A	M	E	NA
Sparganiaceae				
Sparganium eurycarpum (Burr Reed)	O	M	E	NA
Potamogetonaceae				
Potamogeton amplifolius (Pond Weed)	F	W	F	NA
P. pectinatus	O	W	F	NA
Juncaginaceae				
Triglochin maritima (Arrow Grass)	R	SW	E	EU,AS,NA
Alismataceae				
Alisma trivale (Water Plantain)	R	SW	E	NA
Machaerocarpus californicus	F	W	F	P
Hydrocharitaceae				
Elodea canadensis (Waterweed)	F	W	F	NA
Gramineae				
Agropyron desertorum* (Wheat Grass)	F	F	E	EU,AS,NA
Agrostis stolonifera var. major* (Redtop)	C	SW,R	E	EU,NA
Alopecurus geniculatus (Foxtail)	F	SW	E	EU,AS,NA
Beckmannia Syzigachne (Slough Grass)	O	SW	E	NA
Bromus arvensis* (Chess)	F	R	E	EU,NA
B. inermis* (Smooth Brome)	F	R	E	EU,AS
B. tectorum* (Downy Cheat)	C	R	E	EU,NA
Calamagrostis inexpansa (Reed Grass)	F	SW	E	P
Deschampsia caespitosa (Tufted Hairgrass)	F	SW	E	EU,AS,NA
D. danthonoides (Hairgrass)	O	SW	E	SA,NA
Distichlis spicata var. stricta (Salt Grass)	A	SF	L	NA
Elymus cinereus (Wild Rye Grass)	O	SS	E	NA
E. triticoides (Rye Grass)	O	SW	E	NA
Glyceria borealis (Manna Grass)	C	PW	E,S	NA
Hordeum brachyantherum (Barley Grass)	F	SW	E	NA

Appendix I (continued)

	A	H_1	H_2	GD
Graminae (continued)				
Hordeum jubatum** (Foxtail)	F	R	E	NA
Muhlenbergia asperifolia (Scratch Grass)	O	SW	E,L	SA,NA
Phleum pratense* (Timothy)	F	R,SW	E	EU,AS,NA
Poa bulbosa* (Bulbous Bluegrass)	F	SS	E	EU,NA
P. Sandbergii (Sandberg Bluegrass)	F	SS	E	NA
Polypogon maritimus* (Beard Grass)	O	SW	E	EU
Puccinellia Lemmonii (Lemmon's Alkali Grass)	O	SS	E	NA
Triticum aestivum* (Wheat)	O	R	E	EU
Cyperaceae				
Carex athrostachya	O	SW	E	NA
C. nebrascensis (Sedge)	A	SW	E	NA
Eleocharis macrostachya (Spikerush)	A	SW	E	EU,AS,NA
E. montevidensis var. Parishii (Small Spike-rush)	C	SW	E	NA
Scirpus acutus (Common Tule, Bullrush)	A	PW	E	NA
S. americanus (Three-Square)	C	PW	E	EU,AS,NA,SA
Lemnaceae				
Lemna gibba (Duckweed)	F	W	F	EU,AS,NA
Spirodela polyrhiza (Greater Duckweed)	O	W	F	EU,AS,NA,SA
Juncaceae				
Juncus balticus (Baltic Rush)	A	SW	E	EU,NA
J. nevadensis (Wire Grass)	A	SW	E	NA
Liliaceae				
Camassia Quamash ssp. breviflora (Camas, Quamash Lily)	C	SW	E	NA
Zigadenus venenosus (Death Camas)	O	SW	E	NA
Amaryllidaceae				
Brodiaea hyacinthina (White Brodiaea)	O	SW	E	NA
Iridaceae				
Iris missouriensis (Iris)	F	SW	E	NA
Sisyrinchium halophilum (Purple-Eyed Grass)	F	SW	E	P
Salicaceae				
Salix exigua* (Narrow-Leaf Willow)	O	R	WP	NA
Polygonaceae				
Polygonum aviculare* (Common Knotweed)	F	R	L	EU,AS,NA
Rumex crispus* (Curly Dock)	F	R,SW	E	EU,AS,NA
R. triangulivalvis* (Dock, Sorrel)	O	R	E	EU,NA
Chenopodiaceae				
Atriplex heterosperma (Saltbrush)	O	R	S	-
A. rosea* (Redscale)	O	R	E	EU,AS,NA
A. subspicata*	C	SF	E	-
A. truncata (Wedgescale)	O	R	E	NA

Appendix I (continued)

	A	H_1	H_2	GD
Chenopodiaceae (continued)				
Chenopodium album* (Pig Weed, Lamb's Quarters)	O	R	E	EU,NA
C. chenopodioies* (Goosefoot)	O	R	E	EU,NA
Salsola Kali var. tenuifolia* (Russian Thistle)	F	R	S,L	EU,AS
Sarcobatus vermiculatus (Greasewood)	O	SF	WP	NA
Amaranthaceae				
Amaranthus blitoides* (Amaranth)	O	R	S	NA
Caryophyllaceae				
Saponaria officionalis* (Bouncing Bet)	R	R	S	EU
Silene nuda ssp. insectivora (Catchfly)	R	R	E	P
Spergularia marina (Sand Spurrey)	O	SF	L	EU,NA
Stellaria longipes (Chickweed, Starwort)	O	SW	L	NA
Nymphaceae				
Nuphar polysepalum (Cow Lily, Yellow Pond Lily)	O	W	F	NA
Ranunculaceae				
Ranunculus aquatilis var. capillaceus (Water Buttercup)	C	W	F	EU,NA
R. Cymbalaria var. saximontanus (Buttercup)	O	SW	L	NA
R. Flammula var. ovalis (Buttercup)	F	SW	L	NA
R. Macounii (Buttercup)	F	SW	E	NA
Papaveraceae				
Eschsholzia californica (California Poppy)	O	R	E	P
Cruciferae				
Descurainia Sophia* (Tansy-Mustard)	F	R	E	EU,NA
Lepidium campestre* (Peppergrass, Cowcress)	C	R	E	EU,NA
L. perfoliatum* (Peppergrass, Shieldcress)	C	R	E	EU,NA
Rorippa curvisiliqua (Yellowcress)	F	SW	L	NA
Sisymbrium altissimum* (Tumble Mustard)	F	R	S	EU,NA
Thelypodium crispum	O	R,SF	E	P
Thalspi arvense* (Pennycress)	O	R	E,S	EU,NA
Rosaceae				
Potentilla biennis (Cinquefoil, Fivefinger)	O	R	E,S	NA
P. flabelliformis (Cinquefoil, Fivefinger)	C	SW	E,S	NA
Sanquisorba occidentalis (Bernet)	F	SW,SF	L,S	NA
Leguminosae				
Lotus purshianus var. glaber* (Bird's Foot Trefoil)	F	R	L,S	NA
Lupinus confertus (Lupine)	F	R,SS	L,S	P
Mediago lupulina* (Black Medick)	F	R,SW	L	EU,NA

Appendix I (continued)

	A	H_1	H_2	GD
Leguminosae (continued)				
Melilotus albus* (Sweet Clover)	F	R	S	NA
Trifolium cyathiferum (Clover)	O	SW	E,L	P
T. hybridum* (Aliske Clover)	F	SW	E,S	EU,NA
T. repens* (White Clover)	O	SW	L	EU
T. Wormskioldii (Clover)	O	SW	L,S	NA
Geraniaceae				
Erodium cicutarium* (Storksbill, Filaree)	F	R	L,S	EU,NA
Linaceae				
Sclerolinon digynum (Flax)	O	SW	E,L	P
Euphorbiaceae				
Euphorbia serpyllifolia* (Spurge)	F	R	L	NA
Malvaceae				
Malva neglecta* (Mallow)	O	R	S	EU,AS,P
Sidalcea oregana ssp. spicata (Checker)	C	SW	E	P
Onagraceae				
Boisduvallia densiflora	O	SW	E	P
B. glabella	O	SW	L	SA,NA
Epilobium paniculatum var. jucundum (Willow Herb)	C	R	E	P
Oenothera flava (Evening-Primrose)	R	SW	L	NA
O. tanacetifolia	C	R,SW	L	P
Halogoraceae				
Hippuris vulgaris (Mare's Tail)	C	PW	E	G
Myriophyllum spicatum ssp. exalbescens (Water-Milfoil)	C	W	F	NA
M. verticillatum (Water-Milfoil)				
Umbelliferae				
Eryngium alismaefolium	O	SW	L	P
Sium suave (Water-Parsnip)	C	SW	E	NA
Gentianaceae				
Gentiana calycosa (Explorer's Gentian)	R	SW	E	NA
Asclepiadaceae				
Asclepias erosa (Milkweed)	R	R,SW	E	NA
Convolvulaceae				
Convolvulus arvensis* (Bindweed)	C	R	L	EU,AS,NA
Polemoniaceae				
Navarretia minima	A	SW	L	P
Boraginaceae				
Amsinkia Menziesii (Fiddleneck)	R	R	E	NA
Plagiobothrys mollis	A	SW	L	P

Appendix I (continued)

	A	H_1	H_2	GD
Labiatae				
Marrubium vulgare* (Horehound)	O	R	E	EU,NA
Mentha arvensis forma puberula (Mint)	F	SW,R	E	EU,NA
Scrophulariaceae				
Mimulus guttatus (Monkey Flower)	O	SW	E	NA
Orthocarpus hispidus	O	SW	E	NA
O. luteus	O	SW	E	NA
Penstemon Rydbergii (Beard Tongue)	A	SW	E	NA
Verbascum Thapsus** (Common Mullein)	C	R	E	EU,AS,NA
Veronica scutellata (Speedwell)	F	SW	L	EU,AS,NA
Orobanchaceae				
Orobanche californica var. corymbosa (Broom-Rape)	O	SW	E	NA
Lentibulariaceae				
Utricularia vulgaris (Bladderwort)	F	W	F	NA
Plantaginaceae				
Plantago lanceolata* (Ribgrass, English Plantain)	O	R	E,S	EU,NA
P. major var. scopulorum*	F	R	E,S	EU,NA
Campanulaceae				
Downingia bicornuta	F	SW	L	P
Compositae				
Achillea lanulosa (Yarrow)	C	SW	E	NA
Arnica sp.	C	SW	E	-
Artemisia ludoviciana (Wormwood)	O	R,SS	WP	NA
A. tridentata (Basin Sagebrush)	A	SS	WP	NA
Aster adscendens	O	SW	E	NA
Aster sp.	O	SW	E	-
Chrysothamnus viscidiflorus (Rabbit Brush)	C	SS	WP	NA
Circium Drummondii (Thistle)	O	SW	L	NA
C. vulgare** (Bull Thistle)	C	R	E	EU,NA
Conyza canadensis* (Horseweed)	-	R	E	EU,NA
Erigeron peregrinus ssp. callianthemus (Fleabane)	-	SW	E	NA
Gnaphalium palustre (Cudweed, Everlasting)	-	SW	L	NA
Happlopappus lanceolatus	O	SF	L	NA
H. uniflorus	O	SF	E	NA
Iva axillaris* (Poverty Weed)	O	R	L	NA
Lactuca Serriola* (Prickly Lettuce)	O	R	E	EU,NA
Lagophylla ramosissima	-	SW	E	EU,NA
Madia glomerata (Tarweed)	O	R	E	NA
Matricaria matricariodies* (Pineapple Weed)	-	R	E	NA
Senecio integerrimus (Groundsel)	-	SW	E	P
Solidago spectablis (Goldenrod)	-	SW	E	NA

Appendix I (continued)

	A	H_1	H_2	GD
Compositae (continued)				
Tanacetum potentilloides (Tansy)	O	SW	E	NA
Taraxicum officionale* (Common Dandelion)	A	SW,R	L	EU,NA
Tragopogon dubius* (Goat's Beard, Salsify)	F	R	L	EU,NA

Plant species are arranged according to the Herbarium Index, Dalle Torre and Harms with additions from Engler and Diels, Edition 11. Identification and names are according to A California Flora (Munz, 1973) except for Atriplex heterosperma and A. subspicata, supplied by J.T. Howell. Common names are given when available. In many cases, these may be applied to more than one species of a genus. The abbreviations in the columns at the right describe particular characteristics of the species found. The information was derived either from Munz or from field observations. A key to the abbreviations follows.

Abundance:
- R - Rare
- O - Occasional
- F - Frequent
- C - Common
- A - Abundant

Habitat (Association) (H_1):
- W - Water channels
- PW - Perennially wet banks and meadows
- SW - Seasonally wet swales
- SF - Salt (alkali) flat
- SS - Sagebrush scrub
- R - Roadcut

Habit (H_2):
- F - Floating
- L - Low, spreading
- S - Suffrutescent
- E - Erect
- WP - Woody perennial

Geographic Distribution:
- NA - North America
- SA - South America
- EU - Europe
- AS - Asia
- P - Pacific Northwest (only)

Those species marked with asterisk (*) are considered aggressive invaders or weeds.

APPENDIX II

A Preliminary List of Arthropods of the Sierra Valley Marsh

The following list has been prepared to show all arthropod groups identified to date. When available, information regarding general habitat, collecting technique, and study area(s) from which they were collected, are shown for each group. For those groups whose field data has been reviewed, plant or animal associations, when of interest, are also indicated under "Remarks". Other invertebrate groups have been added to the end of this list.

Because water-dwelling insects, other than fly larvae, were given priority, all have been identified at least to genus (with the exception of odonate naiads which are presently being determined by R.W. Garrison), and the entire aquatic collection from each study area has been reviewed. Therefore, when a study area is not indicated for a water-dwelling insect, it can be assumed that the insect was not caught there. This, however, cannot be assumed for the remainder of the species, unless specifically indicated.

Species whose determinations have been verified by specialists are indicated by a double asterisk (**). Those in the process of being determined or confirmed by specialists are indicated by a single asterisk (*). Specialists and groups they work with are listed below.

*	Acalypterate muscoid flies	R.L. Peterson, SFSU
	Ceratopogonidae	R.L. Peterson
	Collembola	R. Kawin, SFSU
	Dolichopodidae	R.L. Peterson
	Empididae	P.L. Phillips, SFSU
	Hippoboscidae	R.L. Peterson
	Machilidae	E. Smith, Cal. Acad. Sci.
	Odonata (immature)	R.W. Garrison, UC Berkeley
	Pipunculidae	R.L. Peterson
	Thysanoptera	R. Kawin
**	Acroceridae	E.I. Schlinger, UC Berkeley
	Anthicidae	K. Hagen, UC Berkeley
	Carabidae	D. Kavanaugh, Cal. Acad. Sci. T. Erwin, Cal. Acad. Sci.
	Chironomidae	G. Grodhaus, Cal. Dept. Publ. Health, Vector Control
	Coccinellidae	K. Hagen
	Dolichopus spp.	R.L. Peterson
	Dytiscidae	H.B. Leech, Cal. Acad. Sci.
	Hydrophilidae	H.B. Leech
	Odonata (adults)	R.W. Garrison
	Silphidae	D. Kavanaugh
	Solpugida	W.E. Savary, SFSU
	Staphylinidae	I. Moore, UC Riverside, Biol. Control
	Tabanidae	C.B. Philip, Cal. Acad. Sci.
	Tephritidae	F.L. Blanc, Cal. Dept. Agric., Div. Entomol.
	Thermacarus nevadensis	V. Lee, Cal. Acad. Sci.
	Pelecypoda	G. Grodhaus
	Annelida	G. Grodhaus

Abbreviations used are as follows:

S. . . . . .Sage	ALT. . . .Aquatic light trap
SG . . . .Saltgrass/flat	DIP. . . .Dip net
MV . . . .Marsh vegetation	FT . . . .Flight trap
W. . . . .Water	NET. . . .Aerial net
A1 . . . .Study Area 1	NLT. . . .Night light trap
A2 . . . .Study Area 2	PFT. . . .Pitfall trap
A3 . . . .Study Area 3	

Group	S	SG	MV	W	Remarks
CLADOCERA					
Daphnia sp.				DIP	A1, A2
				ALT	A1, A2
AMPHIPODA					
Hyalella azteca Saussure				DIP	A1, A2
				ALT	A1, A2
LITHOBIOMORPHA					
at least one species		PFT			A3 only
ARANEIDA					
Araneidae		PFT			
Gnaphosidae		PFT			
Lycosidae		PFT			
Salticidae		PFT			Common but seldom caught
Thomisidae		PFT			
(and other families)		PFT	NET		
ACARI					
Thermacaridae					
**_Thermacarus nevadensis_ Marshall				DIP	Hot creek
(and others)		PFT			A1, A2, A3
SOLPUGIDA					
Eremodbatidae					A1, A2 only
**_Eremobates septentriones_ Muma		PFT			
THYSANURA					
*Machilidae					
(at least one species)		PFT			A1, A2, A3
COLLEMBOLA					
Sminthuridae					
at least one species				DIP	A2
(and others)		PFT			A2
EPHEMEROPTERA					
Baetidae					
Ameletus sp.				DIP	A3

Group	S	SG	MV	W	Remarks
EPHEMEROPTERA (cont'd)					
Caenis sp. (at least one species)				DIP	A1, A3 and fish stomachs
Callibaetis sp. (at least one species)				DIP	A1, A2, A3
Baetidae					
Cloeon sp.					A3
Siphlonurus sp.				DIP	A3
**ODONATA (adults only)					
Aeshnidae					
Aeshna multicolor Hagen				FT	A3
A. californica Calvert	NET			FT	A1
Anax junius (Drury)					Hot creek
Libellulidae					
Sympetrum corruptum (Hagen)	NET	NET			A1, A2
S. pallipes (Hagen)	NET				A1
		NET			A1, A2
			NET		A3
Libellula subornata (Hagen)				FT	A1
L. quadrimaculata L.		FT			A2
					Hot creek
Leucorrhinia glacialis Hagen		FT			A2
Lepthemis collocata (Hagen)					So. hot creek
Lestidae					
Lestes unguiculatus (Hagen)	NET				A1
L. congener Hagen					No. A2
Coenagrionidae					
Amphiagrion abreviatum Selys					
Enallagma carunculatum Morse		FT		FT	A1, A3
E. boreale Selys		FT			A1
Ischnura cervula Selys				FT	A1
		NET			A2
I. perparva Selys		NET			A2
		FT			A2
(additional species from naiads determined thus far)					
Libellulidae					
Erythemis collocata (Hagen)				DIP	Hot creek
Libellula saturata ? Uhler				DIP	Hot creek
Coenagrionidae					
Enallagma civile (Hagen)				DIP	A3
ORTHOPTERA					
Acrididae		PFT			A1, A2, A3
(at least two species)		NET			A1, A2, A3
Gryllacrididae					
at least one species		PFT			A2

Group	S	SG	MV	W	Remarks
ORTHOPTERA (cont'd)					
Gryllidae					
at least one species					A3
Tetrigidae					
at least one species					A3
Tettigoniidae					
at least one species			NET		A1
MALLOPHAGA					
at least one species					Nighthawk
ANOPLURA					
Haematopinidae					
(at least one species)					Rodents
*THYSANOPTERA					
at least one species		PFT			A1
HEMIPTERA					
Belostomatidae					
Belostoma bakeri Montd.				DIP	Hot creek
Lethocerus americanus Leidy				ALT	A1
					NLT-A2
Berytidae					
(at least one species)		PFT			A1, A2
		FT			A2
Corixidae					
Callicorixa audeni Hungerford				ALT	A1, A2, A3
				DIP	A1, A2, A3
Cenocorixa wileyae (Hungerford)				DIP	North of A2
Corisella decolor Uhler				ALT	A1, A3
				DIP	A1, A2, hot creek
Hesperocorixa laevigata (Uhler)				DIP	North of A1, A3
				ALT	A1, A3
Sigara omani (Hungerford)				DIP	A1, A2, hot creek, A3
				ALT	A1, A2, A3
Gelastocoridae					
at least one species					A3, muddy shore
Gerridae					
Gerris incognitus Drake and Hottes					A3
G. incurvatus Drake and Hottes					A3
Lygaeidae					
(at least three species)		PFT			A1, A2, A3
		FT		FT	A2
Miridae					
(at least two species)		PFT			A1, A2
					NET-A2
					FT-A3

Group	S	SG	MV	W	Remarks
HEMIPTERA (cont'd)					
Nabidae					
at least one species		PFT			A3
Nepidae					
Ranatra sp.				ALT	A1
Notonectidae					
Notonecta spinosa (Hungerford)				ALT	A2
				DIP	A1, So. A2, *Hippuris*, *Typha*, A3
N. undulata Say				DIP	A3
N. unifasciata Guerin				DIP	A1, So. A2, A3
				ALT	A1
Pentatomidae					
Species #1				FT	A2
Species #2					A3-willows
Saldidae					
Saldula andrei Drake		PFT			A1, A2
(at least three other species)		PFT			A1, A2
					NET-A3
Tingidae					
at least one species					FT-A3
Veliidae					
at least one species				DIP	A3
HOMOPTERA					
Aphididae					
(at least one species)		FT			A1, A2, A3
				FT	A2, A3
		PFT			A3
Cercopidae					
(at least one species)		PFT			A1, A2
		FT			A2
Cicadellidae					
(at least three species)		PFT			A1, A2, A3
		FT			A1, A2, A3
Cixidae					
at least one species		FT			A2
Delphacidae					
(at least one species)		FT			A1, A2
Membracidae					
at least one species	NET				A1, west of A3
Psyllidae					
at least one species		FT			A2
(and others)					A3
COLEOPTERA					
Anthicidae					
***Anthicus biguttulatus* LeC.					A3

Group	S	SG	MV	W	Remarks
COLEOPTERA, Anthicidae (cont'd)					
***Anthicus punctulatus* LeC.		FT			A3
***Notoxus nevadensis* Cys.		PFT			A1
***Thicanus annectens* (LeC.)		PFT			A1
		FT			A1
(and others)		PFT			A1, A2, A3
Bruchidae					
(at least one species)		PFT			A1, A2
Buprestidae					
Agrilis sp.	NET				A1-*Chrysothamnus*
Cantharidae					
(at least one species)	NET				A1-*Chrysothamnus*
		PFT			A3, NET-roadside
Carabidae***					
***Agonum californicum* Dej.		PFT			A2
***A. subsericeum* LeC.		PFT			A2, A3
***Amara* sp. #1					A1-dung
***Amara* sp. #2		PFT			A2
***Amara* sp. #3		PFT			A2
***Amara* sp. #4		PFT			A2
***Amara* sp. #5		PFT			A3
***Anisodactylus pitychrous* LeC.		PFT			A2
		NET			A1
***Bembidion dejectum* Cys.		PFT			A2, A3
***B. diligens* Cys.		PFT			A2
					NET-A3
***B. ephippigerum* LeC.		PFT			A2
***B. nigripes* Kirby					A3-mud
***B. obscuripenne* Bld.		PFT			A2
***B. obtusangulum* LeC.		PFT			A2
***B. praecinctum* LeC.		PFT			A2
***Bembidion* sp. #1		PFT			A2
***Bembidion* sp. #2		PFT			A2
***Bradycellus* sp. #1		PFT			A3
***Bradycellus* sp. #2		PFT			A2
***Calosoma cancellatum* Esch.		PFT			A2
***Chlaenius harpalinus* Esch.		PFT			A2
***Dyschirius truncatus* LeC.		PFT			A2
***D. integer* LeC.		PFT			A2
***Harpalus* sp. #1					A1-dung
***Harpalus* sp. #2					Coyote, A1-dung
***Harpalus* sp. #3		PFT			A2, A3
***Microlestes nigrinus* Mann.		PFT			A1
***Pterostichus laetulus* LeC.		PFT			A2, A3
***Tachys misellus* LaF.		PFT			A3
(and others)		PFT			A1, A2, A3
		FT		FT	A1, A2

*** Unnamed species are not yet described.

Group	S	SG	MV	W	Remarks
COLEOPTERA (cont'd)					
Cerambycidae					
at least two species	NET				A1-Chrysothamnus
Chrysomelidae					
Donacia sp.				DIP	A3
Galerucella nymphaeae Linn.				DIP	A3-Nuphar sp.
Species #1					A3-willow
(and others)		FT			A2
		PFT			A3
Cicindelidae					
Cicindela sp.					A3
Cleridae					
at least one species					A2-dead cow
Coccinellidae					
**Coccinella monticola Muls.	NET				A1-Chrysothamnus
					A3
**C. novemnotata Hbst.	NET				A1-Chrysothamnus
		FT			A3
**C. transversoguttata richardsoni Brown		FT			A3
**Hippodamia parenthesis (Say)					A3
**H. sinuata disjuncta					A3
**Hyperaspis fastideosa fastideosa Cys.		FT			A3
Species #1		PFT	NET	FT	A1, A2
		FT			A1
(and others)		PFT			A1, A2
		FT			A1, A2
Curculionidae					
Endalis ovalis LeC.				DIP	A2-Juncus
Species #1				DIP	A3
(at least four other species)		PFT			A1, A2, A3
Dermestidae					
(at least two species)		PFT			A1, A2, A3
Dytiscidae					
**Agabus strigulosus Crotch				DIP	A1
		PFT			A2
**Agabus sp. #1		PFT			A1
**Liodessus affinis (Say)				ALT	A1
				DIP	A2-Juncus, A3
**Colymbetes sculptilis Harris				DIP	A1-hot creek
		PFT			A2
**Coptotomus longulus (LeC.)				DIP	A3
**Deronectes griseostriatus (Degeer)				ALT	A1
**Dytiscus cordieri Aube					A1-minnow trap
**D. marginicollis LeC.				DIP	A1-hot creek
Hydroporus sp.				DIP	Dead in hot creek

Group	S	SG	MV	W	Remarks
COLEOPTERA, Dytiscidae (cont'd)					
**Graphoderus occidentalis (Horn)				DIP	A1-sedges
**Hygrotus lutescens LeC.				ALT	A1
				DIP	A1, A3
**H. impressopunctatus (Schaller)				DIP	A1-hot creek, A3
				ALT	A1
				FT	A1
**H. nigrescens (Fall)				ALT	A1
				DIP	Dead in hot creek, A3
**H. tumidiventris (Fall)				ALT	A1
				DIP	No. A2
**Ilybius fraterculus (LeC.)				DIP	A1, A2, A3
					NLT A2
**Laccophilus mexicanus atristernalis Crotch				DIP	A1-hot creek
**L. maculosus decipiens LeC.				ALT	A1
				DIP	A1-Typha
**Rhantus binotatus (Harris)				DIP	A1-hot creek, sedges
**R. gutticollis (Say)				DIP	A1-hot creek, A3
**R. consimilis Motschulsky				DIP	A1-hot creek, A3
and others		PFT			A2 and A3 (larvae)
Elateridae					
(at least one species)		PFT			A1, A2, A3
Gyrinidae					
Gyrinus consobrinus LeC.				DIP	A3
Haliplidae					
Peltodytes callosus (LeC.)				ALT	A1, A2
Heteroceridae					
Heterocerus sp.					A3
Histeridae					
(at least two species)		PFT			A1, A2, A3
					Dead coyote
Hydraenidae					
Ochthebius rectus LeC.		PFT,FT		DIP	A1, A2, A3
Ochthebius lineatus LeC.				DIP	A1, A2, A3
Hydrophilidae					
Anacaena limbata (Fab.)		PFT			A2
**Cercyon kulzeri Knisch				DIP	A2-Juncus
**Enochrus conjunctus (Fall)				DIP	A2, A3
**E. obtusiusculus Motschulsky				DIP	A1-hot creek
**Helophorus spp.				DIP	A2-Hippuris, A3, A1-hot creek
**Hydrobius fuscipes (Linn.)		PFT			A2
					NLT-A2
Hydrophilus triangularis Say					NLT-A2

Group	S	SG	MV	W	Remarks
COLEOPTERA, Hydrophilidae (cont'd)					
**Paracymus subcupreus (Say)				DIP	A2-Juncus
Sphaeridium sp.					A1, A2-dung
**Tropisternus columbianus Brown				DIP	A1
				ALT	A1, A2
**T. lateralis (Fabricius)				ALT	A1, A2, A3
Meloidae					
(at least one species)		NET			A1, A2, A3
		PFT			A3
Melyridae					
at least one species	NET	FT			A1
		PFT			A3
Mordellidae					
at least one species					A1, yarrow
Scarabaeidae					
(at least five species)		PFT			A1, A2
		NET			A1, A2, A3
					Dung
Silphidae					
Nicrophorus sp.					Carrion
**Silpha lapponica Herbst					Carrion
**S. rammosa Say		PFT			A1, A2
					A3
Staphylinidae					
Creophilus maxillosus Gray.					Coyote (dead)
Philonthus lecontei Horn		PFT			A2
					A1-dung
P. aurrelentus LeC.		PFT			A2
P. cruentatus Gmel.		PFT			A2, A3
**Philonthus sp. #1		PFT			A2
**Philonthus sp. #2		PFT			A2
**Neobrisnius sp.					A3
**Gabrius sp.		PFT			A2
Aleochara bimaculata Gray.		FT			A1
**Aleochara sp. #1		PFT			A2
**Aleocharinae spp.		PFT			A1, A2
					A3-along bank
**Tachyporus sp.		PFT			A3
**Leptacinus sp.		PFT			A2
Platystethus americanus Er.		PFT			A2
**Stenus sp.		PFT			A2
**Medon sp.		PFT			A2
**Astenus sp.		PFT			A3
Bledius strenuus Csy.		PFT			A2
(and others)					
Tenebrionidae					
Schizillus sp.		PFT			A1, A2, A3

Group	S	SG	MV	W	Remarks
COLEOPTERA, Tenebrionidae (cont'd)					
at least three other species					A1
(and other families)					
NEUROPTERA					
Chrysopidae					
at least one species					A3
Hemerobiidae					
at least one species					NLT-A1
TRICHOPTERA					
Hydroptilidae					
Ochrotrichia sp.				DIP	(Adults) A2-_Juncus_
Leptoceridae					
at least one species				FT	NET-A3
Limnephilidae					
Desmona bethula Denning					NLT-A1
(and others)					A1, A2, A3
LEPIDOPTERA					
Arctiidae					
Platyprepis virginalis Boisduval		PFT			A2
		NET			A1, A2, A3
Danaidae					
Danaus plexippus (Linn.)		NET			A2
Geometridae					
at least one species					NLT-A2
		PFT			A3
Hesperidae					
at least two species		NET			A3
Lycaenidae					
at least two species		NET			A3
Noctuidae					
(at least five species)					NLT-A1, A2
		PFT			NET-A3
Nymphalidae					
(at least one species)					NET-A1, A3
Pieridae					
(at least four species)		NET			A3
		FT			A2
Saturniidae					
Species #1		NET			A1, No. A2
Satyridae					
at least two species		NET			A3
Syntomidae					
Species #1		NET			A3-roadside
(and others)					

Group	S	SG	MV	W	Remarks
DIPTERA					
Acroceridae					
**Ogcodes adaptatus Schlinger		FT			A1
Agromyzidae					
**Cerodontha dorsalis (Loew)		FT			A1
and others					A3
Anthomyiidae					
(many species)		PFT			A1, A2, A3
		FT		FT	A1, A2, A3
Asilidae					
(at least three species)	NET	NET			A1, A3
		FT			A1
Bombyliidae					
(at least nine species)		FT			A1, A2
	NET	NET	NET	NET	A1, A2, A3
Calliphoridae					
(at least one species)		FT		FT	A2, A3
		NET	NET		A1, A2, A3
Cecidomyidae					
Cordylomyia sp.		FT			A1
(and others)		FT		FT	A2
Ceratopogonidae					
**Atrichopogon occidutalis Wirth		FT			A1
**Bezzia spp.		FT		FT	A2
**Culicoides spp.		FT		FT	A2
**Dasyhelea spp.		FT		FT	A2
(and others)					
*Chamaemyiidae					
at least one species					A3
**Chironomidae					Only specimens from A2 were identified.
Tanypodinae					
Clinotanypus pinguis				FT	A2
Tanypus punctipennis		FT		FT	A2
T. grodhausi		FT			A2
Apsectrotanypus sp.				FT	A2
Procladius bellus		FT		FT	A2
Procladius spp. (probably two)		FT		FT	A2
Ablabesmyia sp.		FT		FT	A2
Conchapelopia sp.		FT			A2
Paramerina sp.		FT			A2
probably two other species		FT			A2
Orthocladiinae					
Cricotopus spp. (two or three species)		FT		FT	A2
Psectrocladius sp.		FT		FT	A2
Smittia sp.		FT			A2
Corynoneura sp.		FT		FT	A2

Group	S	SG	MV	W	Remarks
DIPTERA, Chironomidae, Orthocladiinae (cont'd)					
probably four or five other species		FT		FT	A2
Chironominae					
Tanytarsus spp. (two or three)		FT		FT	A2
Micropsectra nigripila		FT		FT	A2
three or four other spp. of Tanytarsini		FT		FT	A2
Pseudochironomus richardsoni		FT		FT	A2
Parachironomus subaequalis		FT		FT	A2
Paralauterborniella subcincta		FT		FT	A2
Polypedilum spp. (two)		FT		FT	A2
Dicrotendipes nervosus		FT		FT	A2
Chironomus atrella		FT		FT	A2
C. decorus				FT	A2
Chironomus sp.		FT		FT	A2
Harnischia sp		FT		FT	A2
Cryptochironomus sp.		FT			A2
one other species of Chironomini				FT	A2
(and others)		FT		FT	A1, A2, A3
				ALT	A1, A3
				DIP	A1, A2, A3
*Chloropidae					
Cetema sp.		FT			A1
***Meromyza pratorum* Meigen		FT			A1
Siphonella sp.		FT			A2
(and others)		FT		FT	A3
		PFT			A3
Conopidae					
Thecophora sp.		FT			A2
(and others)		FT			A1, A3
				FT	A3
Culicidae					
Aedes dorsalis (Meigen)					NLT-A1
Anopheles freeborni Aitken				DIP	A1
				ALT	A1
					A1, A3-roadside
Culex tarsalis Coquillett					NLT-A1
				DIP	A1, A2
Culisetta inorata (Williston)		FT			A1
					NLT-A1
					A3
(and others)					
Cuterebridae					
at least one species					Removed from *Peromyscus maniculatus*

Group	S	SG	MV	W	Remarks
DIPTERA (cont'd)					
Dixidae					
Dixa sp.		FT			A2
(and others)					A1, A2, A3
*Dolichopodidae					
***Dolichopus amnicola* Melander & Brues				FT	A1, A2, A3
		FT			A1, A2
***D. idahoensis* Aldrich		FT		FT	A1, A2, A3
***D. nigricauda* Van Duzee		FT			A1, A2
				FT	A1, A2, A3
Scellus sp.		FT			A2
Sympycnus sp.		FT			A2
Tachytrechus granditarsus Greene		FT			A1
(at least four other species)					A1, A2, A3
Empididae					
Draptis sp.		FT			A2
(and others)					
*Ephydridae					
Lamprascatella sp.		FT			A1, A2
***Neoscatella setosa* (Coq.)		FT			A1
***Notephila artisetis* Cresson		FT			A2
(and others)					A3
Heleomyzidae					
at least one species		FT			A2, A3
*Hippoboscidae					
Ornithoica vicina (Walker)					Nighthawk
Lonchopteridae					
***Lonchoptera furcata* (Fallen)		FT			A1
(and others)					A3
Millichiidae					
at least one species					A3
Muscidae					
**Haematobia irritans (Linn.)		FT			A1
(and others)					A1, A2, A3
Otitidae					
(at least two species)					A1, A3
Phoridae					
(at least one species)				FT	A2
		FT			A1
*Pipinculidae					
(at least one species)		FT		FT	A1, A2
					A3
Psycodidae					
(at least two species)		FT		FT	A1, A2, A3
Sarcophagidae					
(many species)		PFT			A1, A2, A3
		FT		FT	A1, A2, A3

Group	S	SG	MV	W	Remarks
DIPTERA (cont'd)					
Sciomyzidae					
Phrebellia sp.				FT	A1
(and others)					A1, A3
Sepsidae					
Sepsis sp.		FT			A2
(and others)		FT		FT	A1, A2, A3
Simuliidae					
at least one species		FT			A2
*Sphaeroceridae					
(at least one species)		FT			A1
					A3
Stratiomyidae					
Hedriodiscus sp.				DIP	A1-hot creek
Stratiomys sp.				DIP	A1-hot creed
(and others)		FT		FT	A1, A2, A3
Syrphidae					
Ornithura sp.				FT	A1
(at least nine other species)		FT		FT	A1, A2, A3
		PFT			A3
**Tabanidae					
Chrysops bishopi Bren.		FT			A1
				FT	A3
C. coloradensis Bigot				FT	A3
Hybomitra aasa Phil.		NET			A2
Tabanus productus Hine		FT			A1
				FT	A2
T. punctifer O.S.					A3-Dyson Lane
Tachinidae					
(many species)					A1, A2, A3
Tephritidae					
***Euarestoides acutangulus* (Thomsom)	NET				A3
***Paroxyna clathrata* (Loew)	NET				A1, A3
***P. pygmaea* Novak	NET				A1, A3
***Tephritis ovatipennis* Foote	NET				A1, A2
***Trupanea jonesi* Curran	NET				A1
		FT			A3
(and others)		FT			A2
*Tethinidae					
***Pelomyia coronata* Loew		FT			A1
***Pelomyiella melanderi* Sturt		FT			A1
(and others)					A3
Tipulidae					
(at least one species)		FT		FT	A1, A2, A3
*Trixoscellidae					
at least one species					A3
(and others)					

Group	S	SG	MV	W	Remarks
SIPHONAPTERA					
at least one species					*Peromyscus*
HYMENOPTERA					
Apidae					
(at least one species)	NET	NET			A1, A3
		PFT			A2, A3
Chalcidoidea					
(many species)		PFT			A1, A2
Chrysididae					
(at least one species)		NET			A2, A3
Eulophidae					
at least one species		PFT			A2
Formicidae					
(many species)		PFT			A1, A2, A3
Halictidae					
Nomia sp.	NET	NET			A1-thistle, nesting colonies in salt flats
		PFT			A3
at least one other species		FT			A2
Ichneumonidae					
(many species)		PFT			A3
					A1, A2, A3
Megachilidae					
at least one species					A1-thistle
Mutillidae					
(at least two species)		FT			A2
	NET				A1-sage, roadside
Pompilidae					
Species #1		NET			So. of A1
(at least two other species)		PFT			A1, A2, A3
Sphecidae					
Species #1		NET			A2-colonies near salt flats
(other species)					A1, A2, A3
Vespidae					
Vespula sp.					A1-*Mullein*
(other species)					A3
OTHER INVERTEBRATES					
**PELECYPODA				DIP	A1
**GASTROPODA					
Physidae					
Physa sp.				ALT	A2
				DIP	Hot creek, A1, A2, *Typha*, *Scirpus*

Group	S	SG	MV	W	Remarks
GASTROPODA (cont'd)					
Lymnaeidae					
Lymnaea auricularia				DIP	A1-A2 Pool, open water
Stagnicola sp.				ALT	A2
				DIP	A2
Fossaria sp.				ALT	A2
Planorbidae					
Gyraulus sp.				DIP	A2
Helisoma sp.				ALT	A2
**HIRUDINEA					
Erpobdellidae					
Dina sp.				ALT	A2
				DIP	A1-A2 Pool, *Typha*
Helobdella fusca				ALT	A2

APPENDIX III

Species list of birds in the Marble Hot Springs Study Area (April through September, 1976 and Spring, 1977).

White Pelican

Eared Grebe
Pied-billed Grebe

Great Blue Heron
Common Egret
Snowy Egret
Black-crowned Night Heron
American Bittern
Least Bittern
White-faced Glossy Ibis

White-fronted Goose
Canada Goose
Snow Goose

Mallard
Gadwall
Pintail
Green-winged Teal
Blue-winged Teal
Cinnamon Teal
American Widgeon
Shoveller
Redhead
Ring-necked Duck
Bufflehead
Ruddy Duck
Common Merganser

Turkey Vulture
Red-tailed Hawk
Swainson's Hawk
Rough-legged Hawk
Golden Eagle
Marsh Hawk
Prairie Falcon
American Kestrel
Merlin

Sandhill Crane

Virginia Rail
Sora Rail
American Coot

Killdeer
Black-bellied Plover
Common (Wilson's) Snipe

Long-billed Curlew
Spotted Sandpiper
Willet
Greater Yellowlegs
Lesser Yellowlegs
Least Sandpiper
Long-billed Dowitcher
Western Sandpiper

American Avocet
Black-necked Stilt

Northern Phalarope
Wilson's Phalarope

California Gull
Ring-billed Gull
Forster's Tern
Caspian Tern
Black Tern

Mourning Dove

Barn Owl
Screech Owl
Great Horned Owl
Burrowing Owl

Common Nighthawk

Anna's Hummingbird

Belted Kingfisher

Western Kingbird

Horned Lark

Violet-green Swallow
Tree Swallow
Bank Swallow
Rough-winged Swallow
Barn Swallow
Cliff Swallow

Black-billed Magpie
Common Raven
Common Crow

Long-billed Marsh Wren

Sage Thrasher

APPENDIX III (continued)

Robin
Western Bluebird
Mountain Bluebird

Water Pipit

Loggerhead Shrike

Starling

Orange-crowned Warbler
Yellowthroat

Western Meadowlark
Yellow-headed Blackbird
Red-winged Blackbird
Tricolored Blackbird
Brewer's Blackbird
Brown-headed Cowbird

House Finch
Savannah Sparrow
Vesper Sparrow
Brewer's Sparrow
White-crowned Sparrow
Song Sparrow

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